1953 SEP ... TWO SHILLINGS & SIXPENCE

Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIALS

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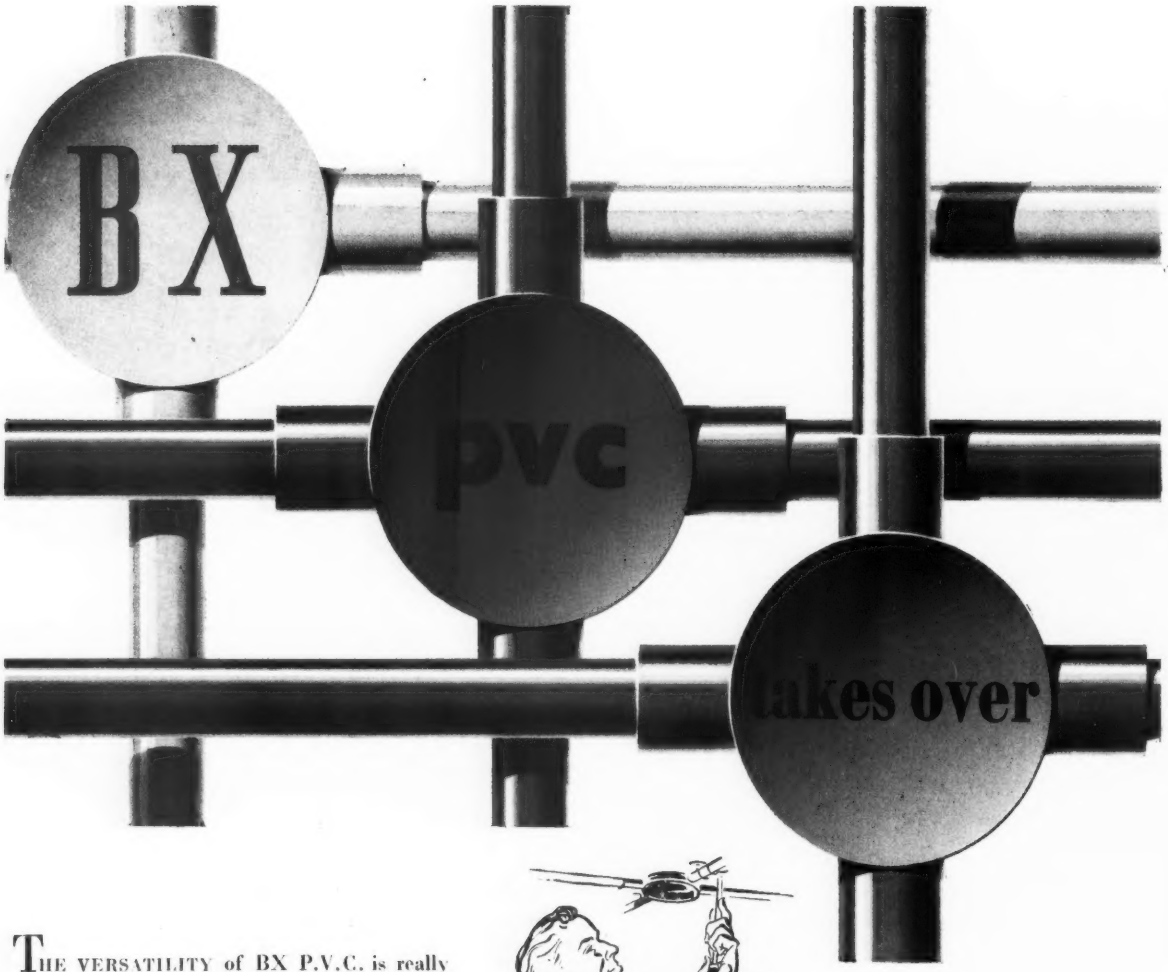
DETROIT

BAKELITE TREFOIL REGD. TRADE MARKS *Urea* MOULDING MATERIALS

BAKELITE LIMITED · 12/18 GROSVENOR GARDENS · LONDON · S.W.1



THE VERSATILITY of BX P.V.C. is really worth your attention, especially when it comes to extrusions. It can be extruded with complete success in every shape and to every consistency, from rigid to fully flexible, from cylindrical tubing to flat solid sections, from fully transparent to completely opaque, and in the widest variety of colours.

BX P.V.C. is also astonishingly tough. Perhaps there is a job BX P.V.C. extrusions could do for you. Why not discuss it with the BX Technical Service Department?

BX PVC EXTRUSIONS

BX PLASTICS LTD., CHINGFORD, LONDON, E.4. . LARKSWOOD 5511

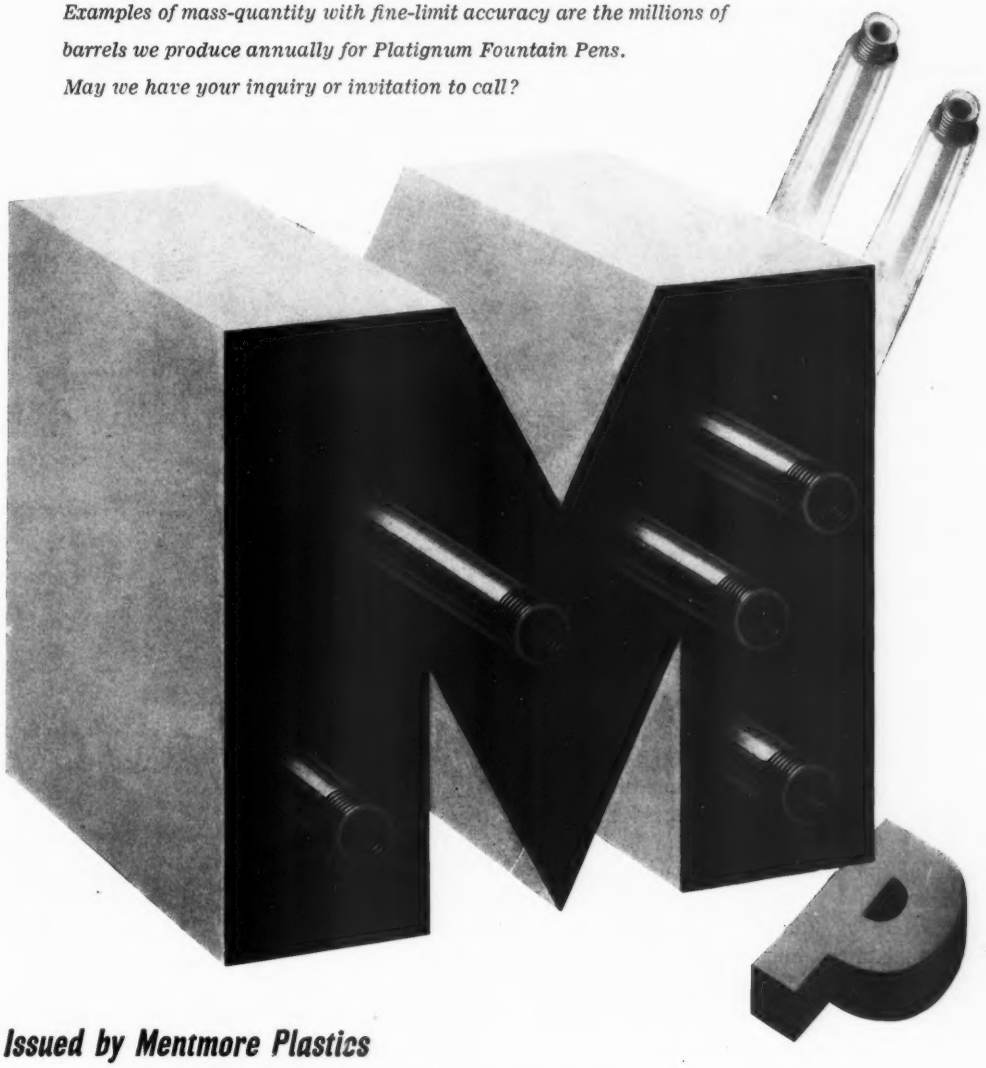
T.A.4592

perhaps we should explain . . .

. . . precisely what Mentmore Plastics have to offer that you need and do not usually find ; what there is about our thermo-plastic injection mouldings service that is a step or two ahead of the field :

Delivery Service: *Count on this to be absolutely exceptional. We promise you the best timetable in the Plastics business -- and keep to it (which is, perhaps, more surprising). Just ask us to prove it.*

Meticulous Accuracy: *We welcome orders for intricate mouldings and guarantee accuracy in all our production. However close the limits imposed we will work to them. Examples of mass-quantity with fine-limit accuracy are the millions of barrels we produce annually for Platignum Fountain Pens. May we have your inquiry or invitation to call?*



Issued by Mentmore Plastics

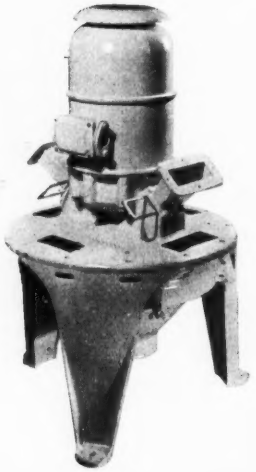
another* Platignum *enterprise

Mentmore Manufacturing Co., Ltd., 1 Bradley Road, Wood Green, London, N.22 Tel: Bowes Park 6021/3

A

MIX IT WITH THE ENTOLETER

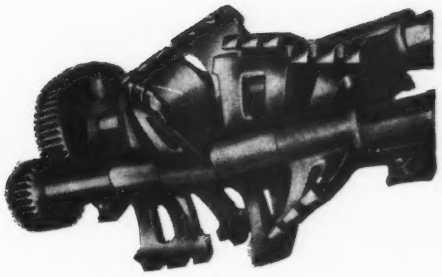
Whatever the mixture you require, there is almost certainly an Entoleter to produce a uniform and intimate blend which is beyond the scope of conventional mixers. Recent successful applications include the blending of:— Moulding compound for gramophone records · Filled phenolic compound for the manufacture of plastic dishes · Filled vinyl moulding compound for the manufacture of storage battery cases, etc. The Entoleter can produce a finished mixture at rates of up to 200 lb./minute, and is easily incorporated as a final mixer in existing processing systems to cut mixing time, reduce costs and improve product quality. Send for leaflet IP1 describing this machine.



Entoleter Centrifugal Machines DISTRIBUTED BY **Henry Simon Ltd** SIMON ENGINEERING GROUP

H.S.127 **STOCKPORT ENGLAND**

How can the TRUE MIX assist your product?



NUMEROUS examples can be given where Beken mixers have assisted manufacturers by making possible economies in processing—

BY MORE THAN HALVING TIME REQUIRED— Synthetic rubber mixed with other materials where time has been cut from 6 to 2 hours; red oxide litharge with acid from 45 to 8 minutes . . .

BY MAKING FURTHER PROCESSING UNNECESSARY— Ensured perfect wetting without agents; with water paints and distempers made milling unnecessary . . .

BY REMOVING ACCEPTED DEFICIENCIES— Overcame balling; degree of wetting hitherto unknown; lumps reduced to powder or plastic state; always a uniform performance permitting minimum production time tables to be fixed; particle size not affected . . .

BY IMPROVING THE FINAL PRODUCT— Complete wetting without resultant lumps; no remaining pockets of unmixed solids; complete dispersion; lower temperature rises . . .

but every material has its own peculiarities, no generalisation can be made for mixing differing materials. The more difficult the mixing problem invariably the greater is the supremacy of the Beken mix.

Let us prove this fact by trying your product and show what TRUE MIXING can save you in time, power and cost.

THE DBEKEN MIX is the TRUE mix

'DUPLEX' HORIZONTAL MIXERS
Sizes from 155 *c.c. to* 500 *gallons*

'PLANETEX' VERTICAL MIXERS
Sizes from 5 *gallons to* 100 *gallons*

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103 KINGSWAY, LONDON, W.C.2
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Rover Car Factory, Solihull. High intensity lighting in a body spray tunnel by fluorescent lamps in a glazed enclosure.

Tailored for the job

The lighting of many processes is vital to the smooth and rapid flow of work and to the quality of the finished product. For example, poor lighting could make a spray tunnel into a bottle-neck — each job taking a little too long, a little portion missed, a return to the spray line — and so the whole production line marks time. Whatever form it takes, good lighting not only helps to provide a satisfactory working environment but is an active production tool.

Fluorescent lighting is as good as daylight — only more consistent. It is efficient; it is economical; and it is *flexible*. You can ' tailor ' it, easily and exactly, to the special requirements of production at all stages.

HOW TO GET MORE INFORMATION

Your Electricity Board will be glad to advise you on how to use electricity to greater advantage — to save time, money, and materials. The new Electricity and Productivity series of books includes one on lighting — " Lighting in Industry ". Copies can be obtained, price 9/- post free, from E.D.A., 2 Savoy Hill, London, W.C.2, or from your Area Electricity Board.

Electricity for PRODUCTIVITY

Issued by the British Electrical Development Association

ANOTHER BX *PRODUCT*

VELBEX
P.V.C PRINTS

A colourful and attractive series of original printed designs on P.V.C.

VELBEX HOUSEHOLD RANGE
suitable for curtaining, toilet bags, dress covers, make-up capes and other toilet articles and fancy goods.

VELBEX 'AQUA' RANGE
of latest patterns for plastics rainwear.

•

Our standard range also includes:—

Velbex P.V.C. Thin Sheet (Plain, embossed and laminated)

Velbex P.V.C. Thick Sheet (Plain and embossed)

Velbex P.V.C. Tape

BX PLASTICS LIMITED

HIGHAM STATION AVENUE, CHINGFORD, E.4. *Telephone: LARkswood 5511*

T.A.6128

PVC

It will pay you to use Grist 1st quality PVC extrusion compound

The use of a top quality material need not increase your production costs—Grist extrusion compound is the answer. We shall be pleased to send you samples.

Have you tried Grist Reprocessed Polystyrene and Cellulose Acetate in metallic colours?

If you wish to dispose of scrap C. A. polystyrene, PVC or polyethylene, please let us know, and we will gladly quote for it.

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LIMITED

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ONE OF THE DOHM GROUP OF COMPANIES

We welcome enquiries for reprocessing customer's own material into any colour, including metallics.

One OPERATIVE TENDS *Six*

CUTS MOULDING TIMES & COSTS

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SIMPLE TOOLING ENABLES RAPID MARKETING

FASTER THAN ANY COMPARABLE MACHINE

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Fully Automatic Fast-Cycling

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Up to 1,200 cycles per hour

Fully automatic and foolproof

Fast plasticizing at unusually low injection pressure

Automatic lubrication

3-zone cylinder heating

Vickers-Detroit hydraulic equipment

BRITISH MADE

SPECIFICATION

Approximate weight of material plasticized per hour (Dependent upon weight per shot and material used)	22 lb.
Area of Injection plunger	2·074 sq. in.
Pressure per square inch on material at end of plunger	9,100 lb.
Total pressure on Injection plunger	18,850 lb.
Mould opens (adjustable)	6—9 ins.
Maximum die space	7 in.
Minimum die space	3 in.
Maximum recommended casting area in mould	15 sq. in.
Size of die plates	16 x 10 in.

EARLY DELIVERY

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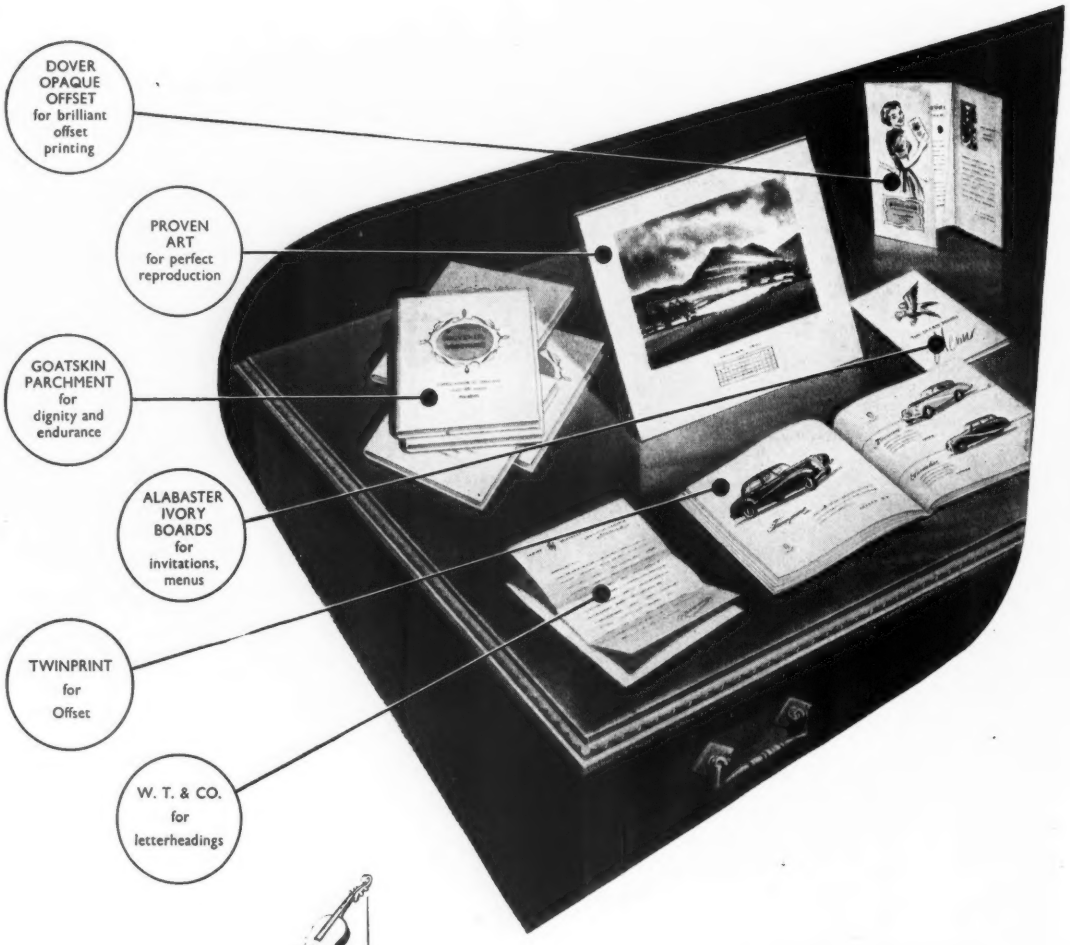
DOVER OPAQUE OFFSET for brilliant offset printing
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ALABASTER IVORY BOARDS for invitations, menus
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Paper is vital in every department of advertising and publicity. It is used from the inception of an idea or design through the various stages to the completed work. Writing, ledger and filing papers in the office, drawing, detail and tracing papers in the art studio, and papers for printing and the fabricating of displays — all these papers are made by Wiggins Teape and all the papers made by Wiggins Teape are the best of their kind. Samples of these and many other quality papers are available on request

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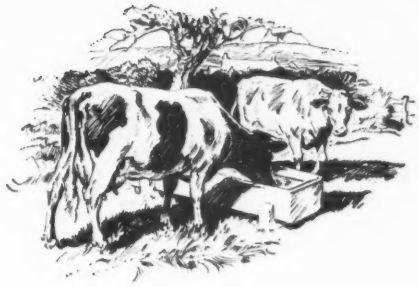
Serve the Farmer

Modern farming techniques call for hygienic and well-lit barns, byres and sheds. To ensure the maximum daylight in their out-buildings farmers specify corrugated 'Perspex'. This acrylic sheet is simple to fix, is available to match any standard roofing corrugations, whether the roof is straight or rounded and transmits no less than 92% of natural light. When used for cattle sheds it benefits the stock too, since corrugated 'Perspex' transmits health-giving ultra violet light.

I.C.I. also serves the farmer by supplying tough, flexible 'Alkathene' tube, made from the I.C.I. brand of polythene. This tubing answers the farmers' need for water service lines that are adaptable and easy to install, durable as conventional 'permanent' materials, proof against frost bursts and immune to corrosion from soils or water.



'Perspex' and 'Alkathene' are registered trade marks, the property of Imperial Chemical Industries Ltd.

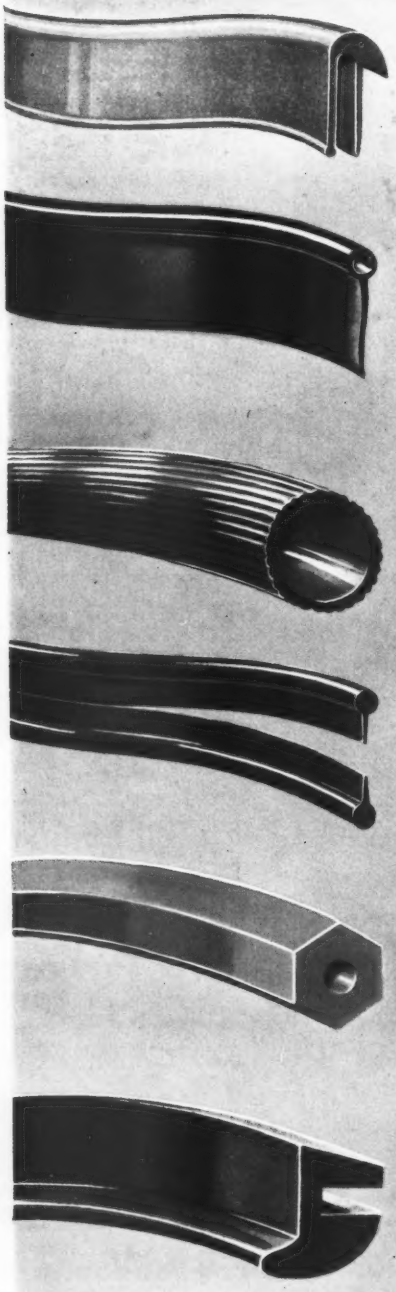
IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

Export enquiries should be addressed to : Imperial Chemical Industries Ltd., Plastics Division, Black Fan Road, Welwyn Garden City, Herts, England.

P.528

B

EXTRUSIONS



to meet your every need are made by

There's variety, there's range, for every need in Commercial Plastics' EXTRUSIONS, but you will find a constant factor in every product—the fine quality of workmanship, the extra touch of excellence that only the most modern methods and machines can give.

Commercial Plastics produce Viny extrusions with a very wide range of applications for the electrical and general industries and normal requirements can be met promptly. I you have special needs, our research and development department is always ready to collaborate with you to produce new applications.

CP

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MANCHESTER OFFICE: *Messrs. Harold Franks & Co. Ltd., 195, Gre:ngate Salford, 3. Deansgate 8031/2,3*

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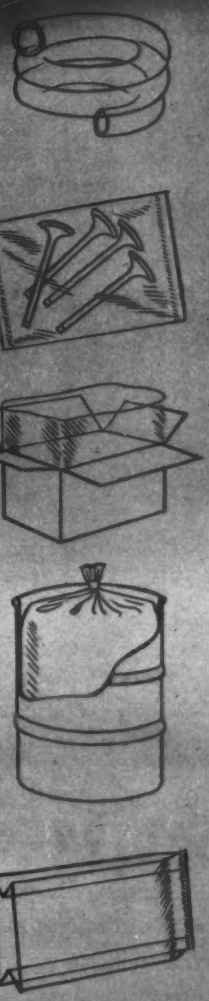
Commercial Plastics Ltd

NEW – layflat Polythene tube

'FABLOTHENE'

(Registered Trade Mark)



Here comes 'FABLOTHENE'—the latest and best in polythene layflat tube—to solve modern packaging and lining problems. Readily sealed into bags and envelopes, made up as drum and case linings, 'FABLOTHENE' is available in tube widths of 2″ up to 30″ and thicknesses ranging from .0015″ to .005″. Keeping in—and keeping out moisture, excluding contamination, sealing in freshness, 'FABLOTHENE' preserves what it shows—simply, attractively and more efficiently.

'FABLOTHENE' is also available in heavy gauge tubing for the permanent conveyance of liquids for industrial, commercial and domestic uses.

Packaging with ▲ *a lasting future*

Fablothene *is completely inert, tough, extremely flexible, odourless, tasteless, waterproof and resistant to bacteria, fungi and mould.*

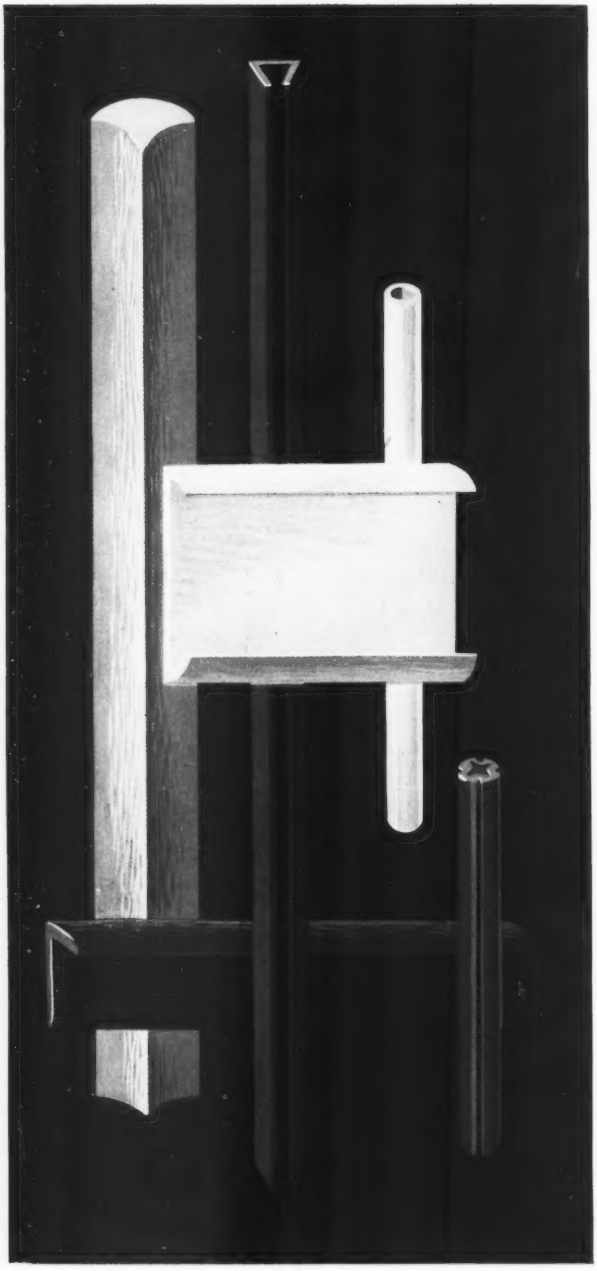
Fablothene *has a very low moisture-vapour transmission rate, contains no plasticizer or other additions, and is non-toxic.*

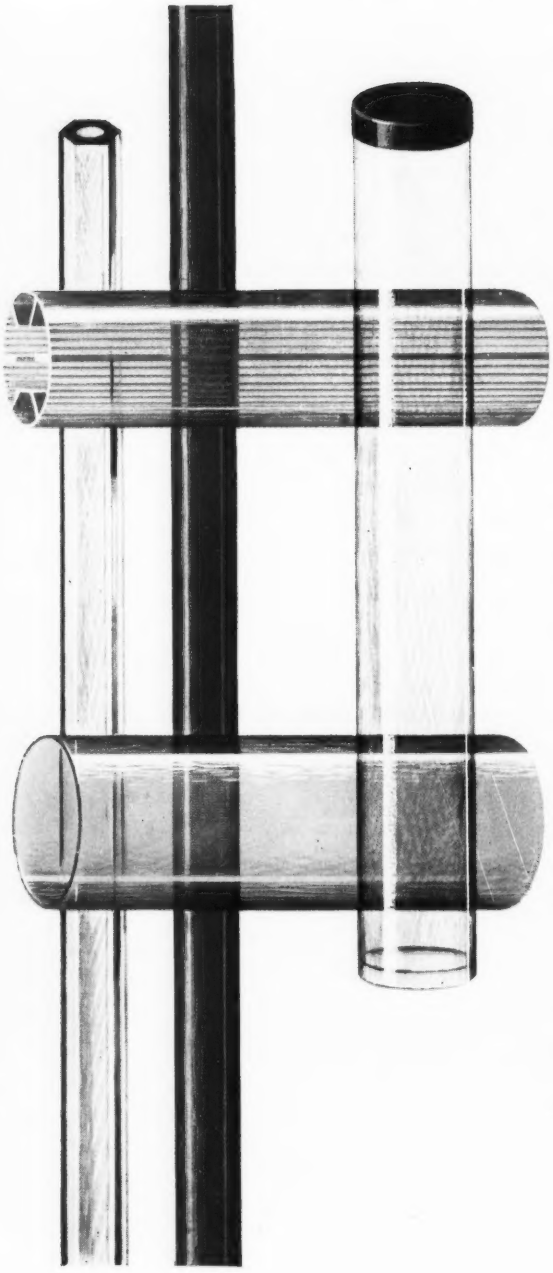
Fablothene *makes economical drum and case linings and is an effective packing for wet, dry or frozen foods, electrical and engineering parts, chemicals, confectionery, clothes, etc. etc.*

Fablothene *will not be affected by extremes of cold and heat and is completely stable from 40 C to 100 C. It does not become brittle when frozen.*

WRITE FOR FULLY DESCRIPTIVE LITERATURE AND SAMPLES

Anglo-American Plastics Ltd





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Tell us precisely what you want in an Extrusion—how opaque or transparent, how rigid or flexible : give us an exact brief about profile ; nail us down on colour. You'll find we have a way of coming up with just the right answer —not to mention saving you metal, machining and money. Everyone has a job that a De La Rue Extrusion could do—what's yours?

★*In Cellulose Acetate, Polythene, Polystyrene, P.V.C. Rigid and Flexible, Cellulose Acetate Butyrate.*

EXTRUSIONS
DE LA RUE

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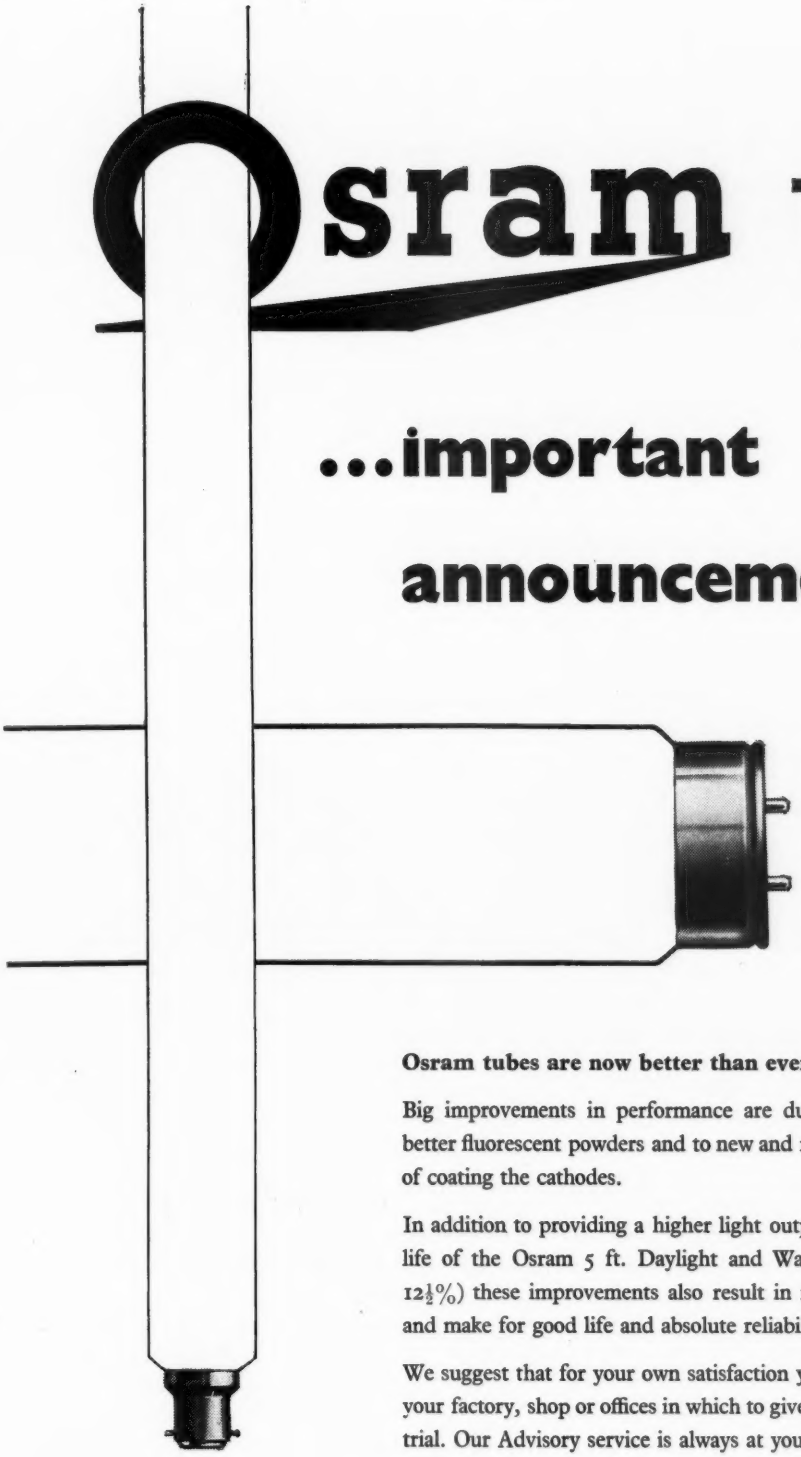
Osram TUBES

...important announcement



Osram tubes are now better than ever.

Big improvements in performance are due mainly to the use of better fluorescent powders and to new and much improved methods of coating the cathodes.

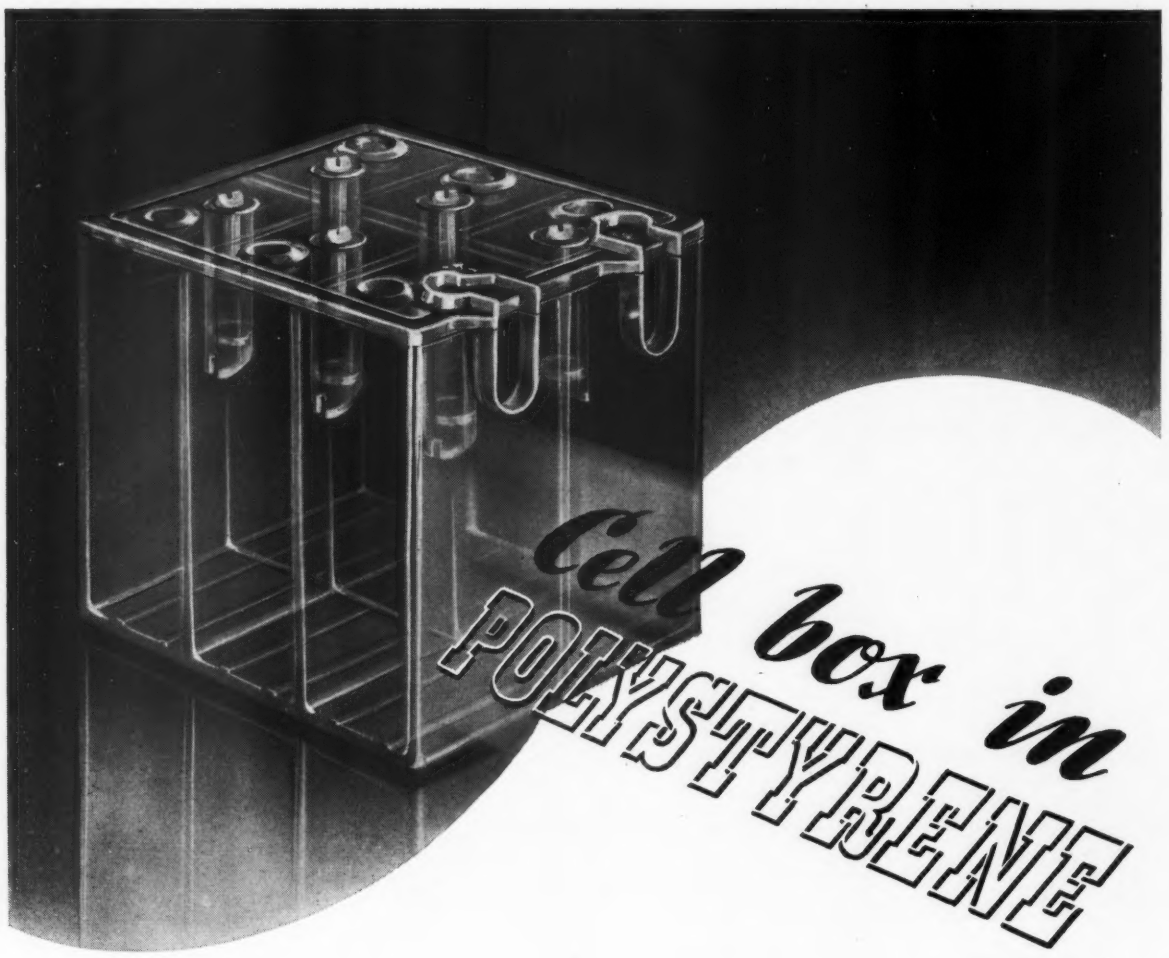
In addition to providing a higher light output (the average through life of the Osram 5 ft. Daylight and Warm White is now up by 12½%) these improvements also result in much greater uniformity and make for good life and absolute reliability.

We suggest that for your own satisfaction you set aside a section of your factory, shop or offices in which to give Osram tubes a thorough trial. Our Advisory service is always at your disposal.

Osram tubes for STAMINA

A G.E.C. Product The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2

C



Cell box in POLYSTYRENE

P & B

INJECTION MOULDING *Specialists*

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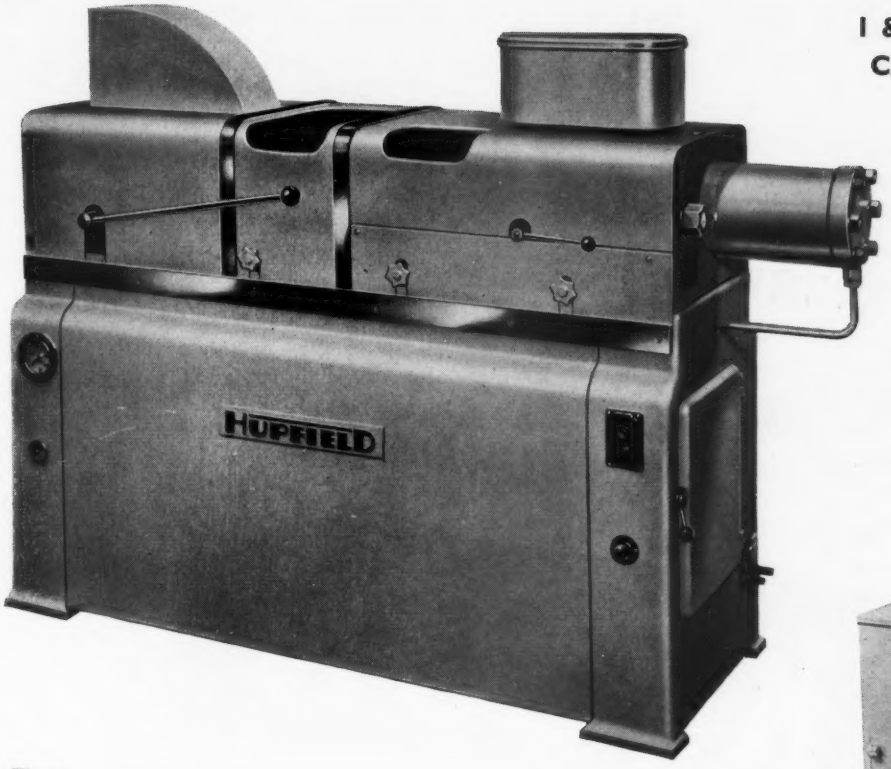
Telephone: COLINDALE 7160 & 7956 *Telegrams:* PUNFIBARS, HYDE, LONDON

HUPFIELD Plastics

INJECTION MOULDING MACHINES
FOR ECONOMICAL PRODUCTION

1 & 2 OUNCE
CAPACITIES



These
low priced hydraulic
operated moulding machines, are
designed for the rapid production of thermo-plastic mouldings on a low cost basis. Being operated by a single lever they are simple to use, ideal for female labour. Fitted with compensating feed mechanism and the latest Tem-Con automatic temperature control. All parts are standardized.

Completely self-contained with electric motor.

Machine moulding capacity	1 oz.	2 oz.
Moulding area up to	12 sq. in.	22 sq. in.
Plasticizing capacity per hour	11 lb.	22 lb.
Shots, subject to mould design	350 per hr.	250 per hr.

This
fully enclosed machine
will granulate any type of thermo-plastic material, is very rapid and smooth in action. The cutting blades are adjustable and can be very quickly cleaned.
Completely self-contained with 2 H.P. electric motor.

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AKULON

AKULON is an outstanding (nylon) type material which possesses highly interesting characteristics.

AKULON is of interest to the industrial field employing plastics for mechanical and constructional components where high strength, extreme toughness and resistance to heat are necessary.

AKULON can be supplied in the form of granules for injection and extrusion and cylindrical rods for machining.

Informative literature covering the characteristics for the moulding granules, rod materials and full technical data of AKULON will gladly be sent on request.

Manufactured by:—

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This Trophy was a winner in more ways than one

Although the true spirit of open competition is the pleasure which results from participating, we would not be human if we did not look forward to receiving some token of our prowess. This fact was recognised by the British Federation of Music Festivals when they organised a series of open competitions on the occasion of the Festival of Britain. The Federation decided to award the winners in each class with a plaque as a permanent memento. As the occasion demanded, something special was required, and in the open competition for the design and production we were awarded the contract.

In all modesty we suggest that this really beautiful ivory urea moulding measuring $7\frac{1}{2}'' \times 4\frac{3}{4}'' \times \frac{1}{2}''$ has to be seen to be believed. Even the smiles and the finger nails of the three bas-relief figures are clearly discernable. No photograph could do it real justice.

CONSOLATION FOR A GOOD TRY

A perfect miniature reproduction (size $2\frac{1}{4}'' \times 1\frac{1}{2}''$) plaque was presented to all finalists. We again made the dies and produced the mouldings.

One of the three bays in our Compression Moulding Shop.

E. Elliott LIMITED

THE MOULDERS WITH THE ENGINEERING BACKGROUND

★ *THREE FACTORIES AT YOUR SERVICE* ★

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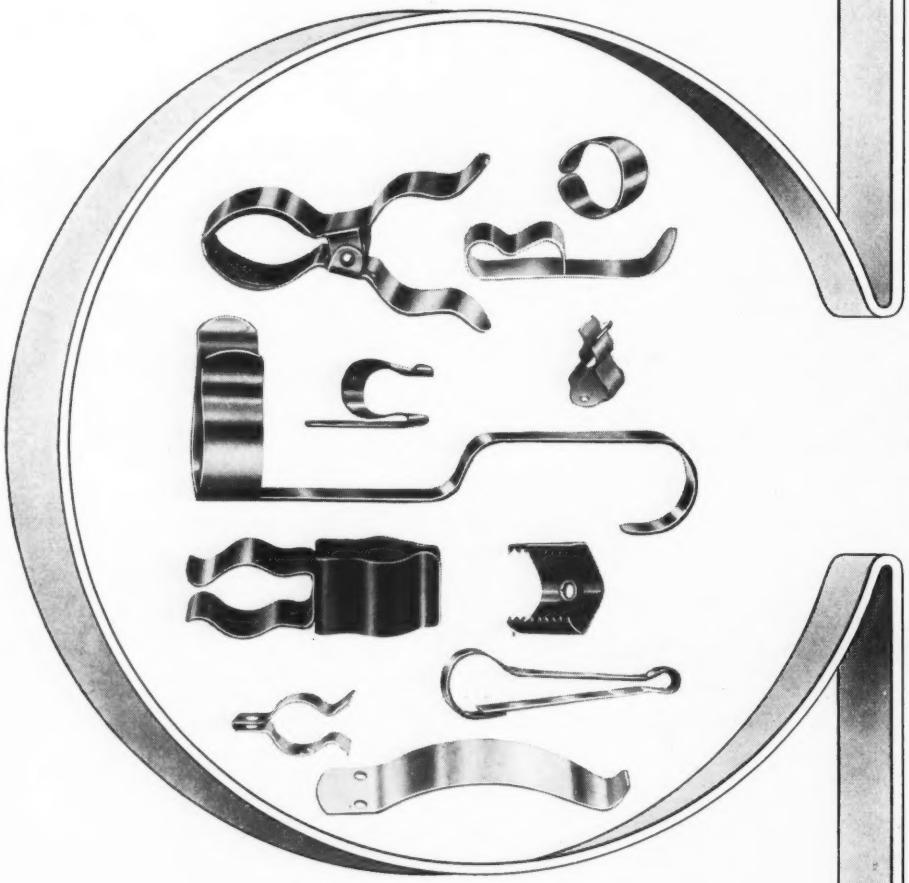
How are you fixed for CLIPS?

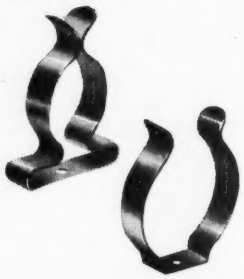
If you are having trouble with clips, bring your problem to us. We show here a few varieties, but these, mark you, are only a **very** small selection from our range of thousands of CLIPS . . . in every possible shape, size and quantity — in phosphor-bronze, brass, steel, stainless, plated . . . for every trade and profession.

And if you want a 'special' let TERRY'S Research Department design for you — after all, we've got 98 years' experience behind us.

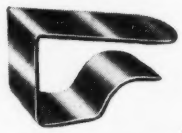


and 5 very popular 'numbers'

80 and 81 — general utility clips — for tool racks, etc., from $\frac{1}{4}$" to 2" from stock.

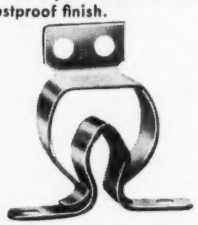


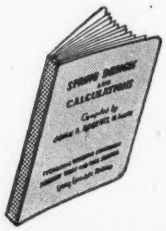
300 — an exceptionally efficient drawing board clip, 5/- a doz. (inc. p.t.) from stock.



257 — a useful clip in black enamel, from $\frac{3}{8}$" to $1\frac{1}{2}$".

1364 — a clip for kitchen cabinets — rustproof finish.





Really interested in springs? *This book* — **Spring Design and Calculations** — *packed from cover to cover with spring data, is yours post free for 12/6.*

TERRY *Clips*

Sole Makers:

HERBERT TERRY & SONS LTD. REDDITCH (The Spring Specialists)

BIRMINGHAM · LONDON · MANCHESTER

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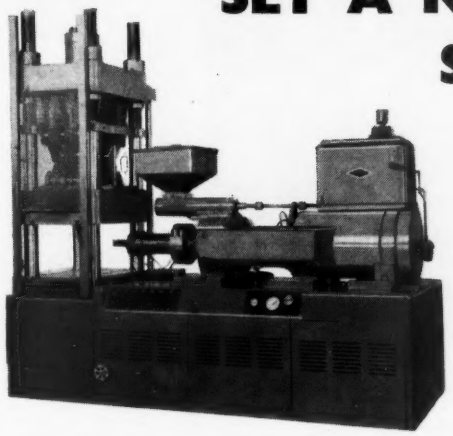
SET A NEW STANDARD FOR SPEED AND QUALITY

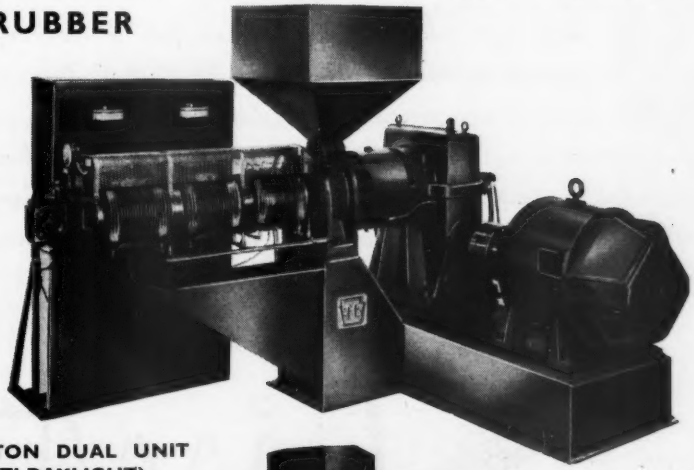


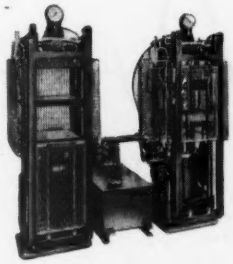
IMPCO INJECTION - COMPRESSION MACHINE

A 500-ton Downstroking Press for clamping and 100-ton Upstroking Transfer Ram which may be used to give additional pressure to eliminate shrinkages or flow marks. Used to shear gates, pierce or engrave under part of moulding, or to eject. The horizontal injection is of conventional type and may be supplied with interchangeable cylinders. Also with nylon moulding equipment. Capacities from 8-32 ounces. With pre-plasticiser up to 150 ounces. The perfect machine for use with Metal inserts.

THE 'DAVIS-STANDARD' RANGE OF EXTRUDERS FOR PLASTICS AND RUBBER

Available in sizes from 2" upwards Davis-Standard extruders assure high velocity extrusion and maximum operating efficiency. Equipped for profitable production with the most silent and speedy Pay-Off, Capstan and Take-up accessory units.





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For Plastics and Rubber

Equipped with high-speed rams. Variable pressure control up to 3,360 lb. p.s.i. Patent electric 14" × 14" hot plates. 8" Rams with 8" stroke with adjustable daylight. Completely self-contained with pump and motor.

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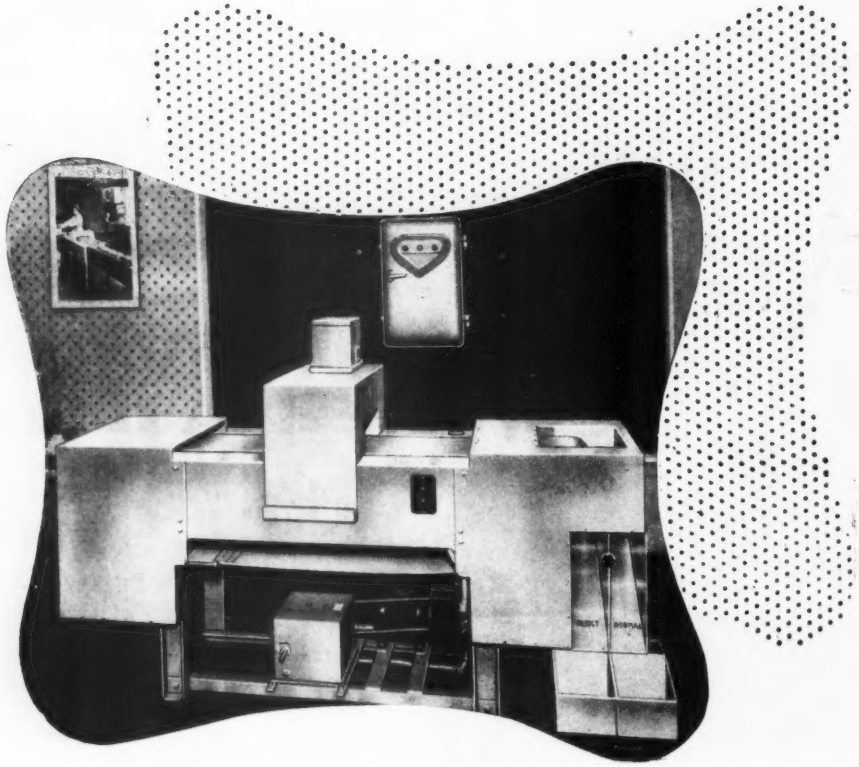

The ' Cintel ' Industrial Electronic Metal Detector Type 3.

This is the latest Cintel Detector, the outcome of years of laboratory research, combined with sound practical experience. It will locate and automatically eject an article containing any metal, ferrous or non-ferrous, and also give a warning alarm.

The equipment is individually tailored to suit your product and thus maximum efficiency is obtained in every case. Hundreds of these detectors are already operating in this country alone, and if you have not yet had full details of this newest Cintel equipment, please write today.

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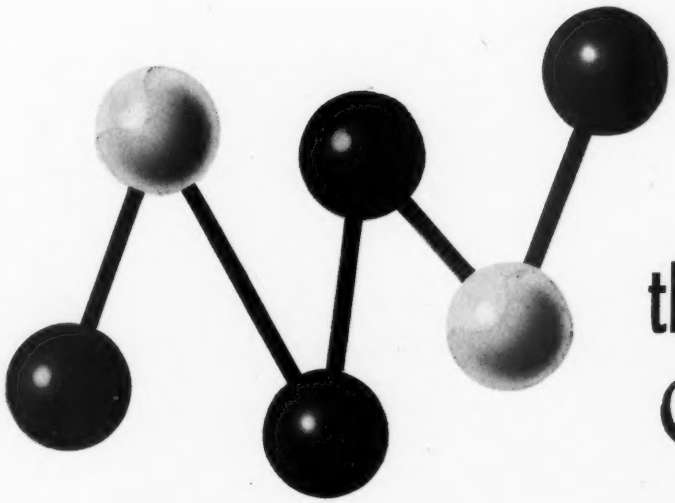
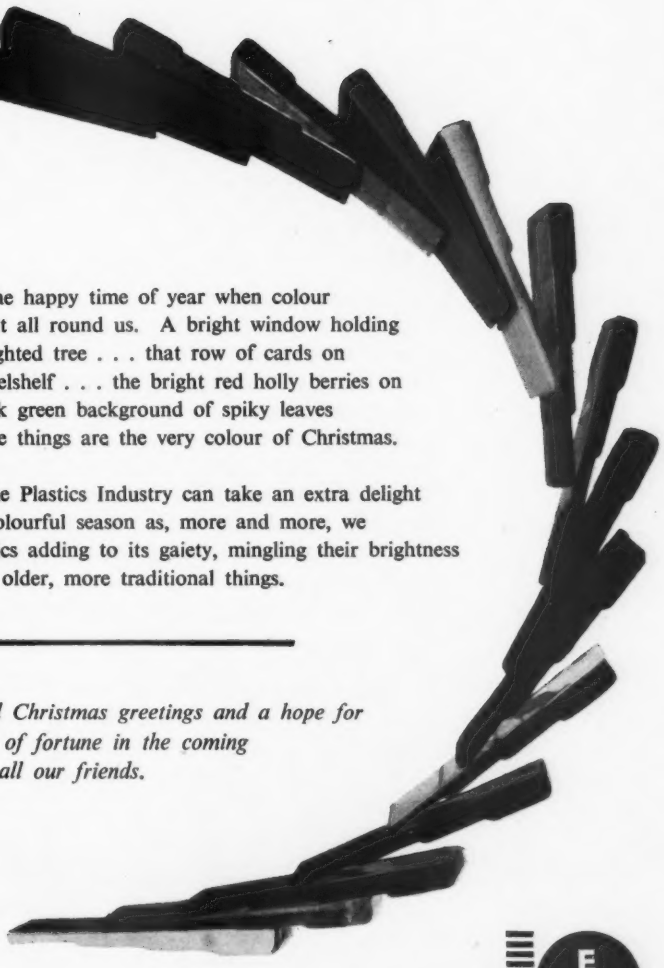


the colour of Christmas...

This is the happy time of year when colour bursts out all round us. A bright window holding a fairy-lighted tree . . . that row of cards on the mantelshelf . . . the bright red holly berries on their dark green background of spiky leaves . . . these things are the very colour of Christmas.

We in the Plastics Industry can take an extra delight in this colourful season as, more and more, we see plastics adding to its gaiety, mingling their brightness with the older, more traditional things.

We send Christmas greetings and a hope for the best of fortune in the coming year to all our friends.



EAST ANGLIA PLASTICS LTD.

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D

Ingot Cogging Mill

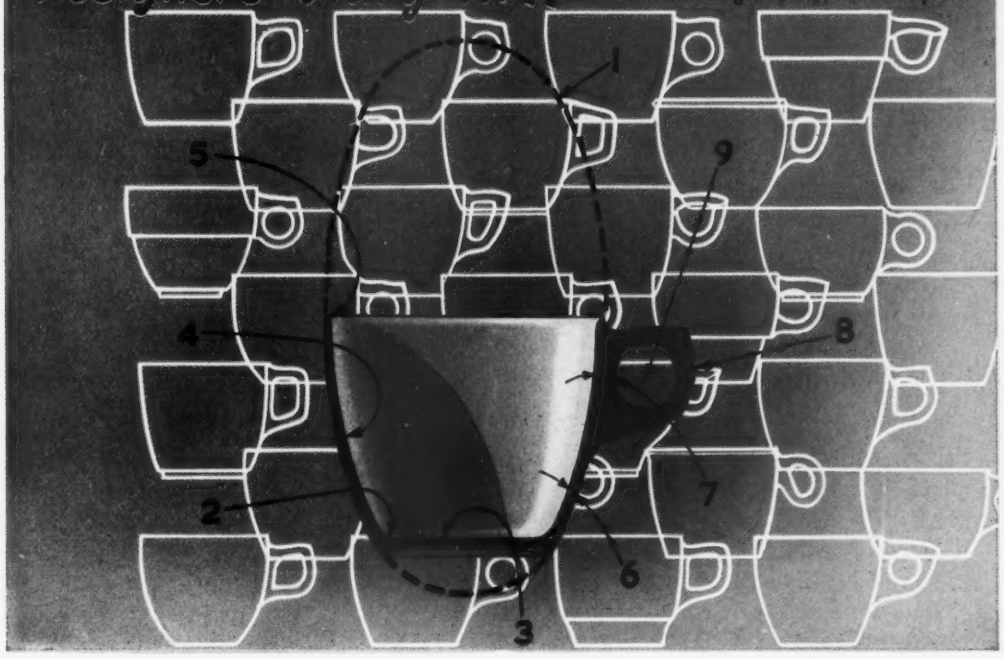
FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · HEAVY ENGINEERS

THOS. FIRTH & JOHN BROWN LIMITED · SHEFFIELD

Designer's Diary No. 11

Reprints of these announcements will be gladly supplied on request.



The Problem of moulding a simple drinking cup in Melamine is a major one, flow lines, flash lines, surface finish, thickness, the hole through the handle and mould costs being but a few of the problems involved. Many of these difficulties can, of course, be overcome by moulding technique, but for those in the industry who may contemplate entering the field of moulded tableware, or those who consider purchasing it for the first time, B.I.P. Designers illustrate a hypothetical cup conceived to avoid at least some of the known pitfalls.

The Design

1 Underlying basic oval shape depicts ideal moulding form.

2 Inside contour generously rounded to facilitate cleaning. Note also the lack of square corners on underside of foot.

3 Inside bottom of cup is flat for easy cleaning.

4 Thickness gradually diminishes towards drinking lip.

5 Inner edge of thickness well radiussed to provide pleasing touch to the lips.

6 The general thickness of 0.125 in. is considered correct for normal usage. Up to 0.156 in. may be necessary for extra heavy duty, or down to 0.080 in. for smaller cups for light usage.

7 To help safeguard against "knit lines" forming on the inside of the cup, the general thickness of the handle should be as close as possible to that of the cup bowl.

8 Flash line position is not very important on this type of handle, the top half of which is formed by the punch. Experience suggests that a lower position is better than a flash line near the top of the handle.

9 A circular hole through the handle permits flash corners around its edges to be removed mechanically. Departing from the circle complicates tooling and necessitates finishing by hand. On the other hand, such a design leaves a thick section of material where the handle joins the bowl, which can aggravate the problem of knit lines.

The Material

Beetle MELAMINE is recommended as an excellent material for moulded tableware, as it is one of the hardest aminoplastics developed to date. It is odourless and tasteless, whilst its lustrous, scratch-resistant surface is particularly resistant to staining from natural oils, fats, weak acids, etc. Beetle MELAMINE is available in a selective range of subtle colours.

The B.I.P. Technical Advisory Service is always ready to help moulders in any problem which may arise regarding product design, mould design, materials and moulding techniques. This consultative service is freely offered, without obligation, and applies to moulding in thermoplastic as well as thermosetting materials.

BRITISH INDUSTRIAL PLASTICS LIMITED B·I·P GROUP **1 ARGYLL ST., LONDON, W.1**

'BEETLE' is a trade mark registered in Great Britain and in most countries of the world

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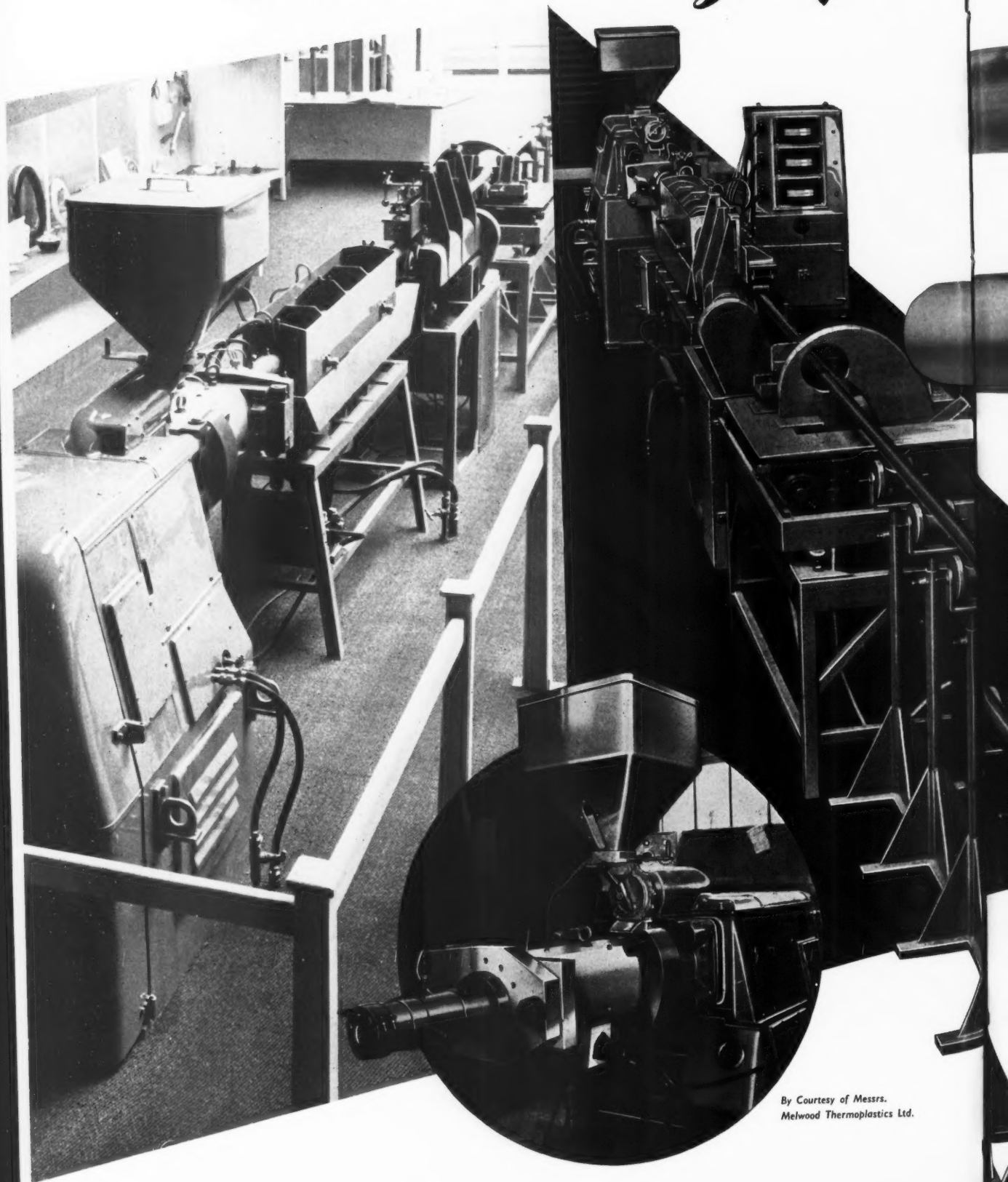
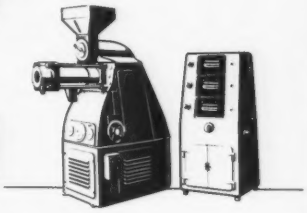


By Courtesy of Messrs.
Melwood Thermoplastics Ltd.

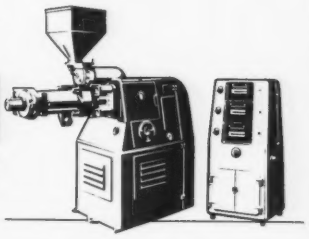
...action extruders

By Courtesy of Messrs. L.M.P. Torino, Italy.



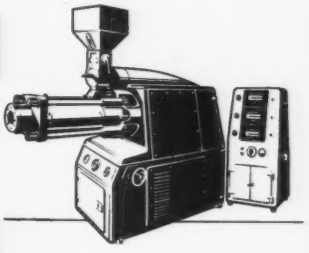
THIS *is a twin-screw variable speed extrusion and compounding machine with an hourly output of 65 lb. plus. An automatic feeding device for metering plastic material to the extrusion screws is incorporated and automatic heating regulation is provided.*

R.C.65



THE *R.C.100 twin-screw machine is a medium capacity extruder with a nominal output of 100 lb. per hour and will operate continuously over long periods, producing tubes, rods and sections in thermoplastic materials. Coated cables, rods and tubes are standard jobs.*

R.C.100



THREE *screws provide this heavy duty machine with exceptional mixing powers. With a nominal output of 200 lb. per hour, constant extrusion pressures, and trouble free operation, it satisfies the demand for a multi-screw machine of really high output.*

R.C.200

R.H.
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P.V.C. extrusions

M. & I. are suppliers of P.V.C. extrusions for a variety of purposes

"MICOFLEX-DURATUBE"

sleeving in a wide range of sizes, in many colours and several degrees of hardness, including heat resisting and clear translucent grades.

"MICOFLEX-DURATUBEX"

P.V.C. sleeving covered with non-fraying cotton braid to support the plastic during close soldering operations and processed to resist fungus growths.

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plastic covered metal conduit for a number of uses such as protection of trailing cables in proximity to acids, gases and heavy condensations, as gas hose or suction hose, and as a protection for flexible leads and electrical connections on machine tools and motors.

"DURAJOINT"

An improved extensible watertight expansion joint for use in concrete structures and particularly where water pressure is involved. A special patented cross section is employed to ensure effective bonding to the concrete.

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A watertight seal between adjacent sections of the concrete lining of tunnels.

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in insulating grades for covering bus-bars etc., or in non-insulating grades in a wide range of ornamental designs for carry-handles for portable radios and similar applications.

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P.V.C. thread for cable lacing, in diameters ranging from 0.75 m/m.

"KENUTUF" INJECTION MOULDINGS

in P.V.C. Cellulose Acetate, Polystyrene as well as other plastics.

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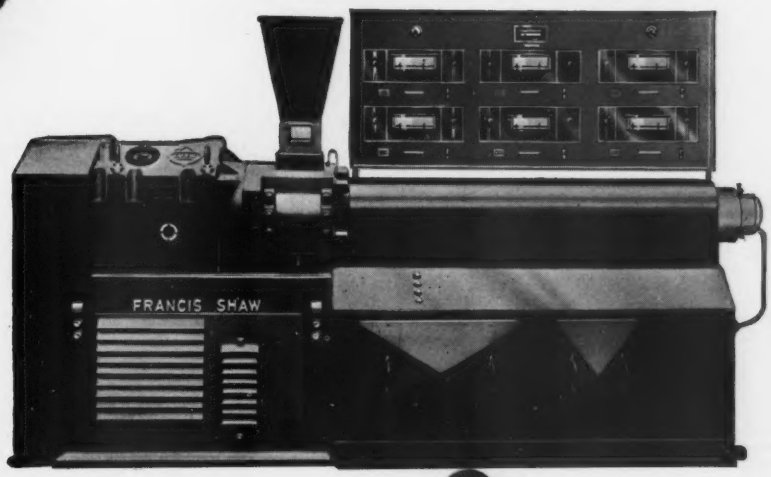
SHAW

for extrusions like these . . .

The Shaw 4½" Plastic extruder is specially designed for the continuous production of belting, tubing, miscellaneous sections and for the insulating and sheathing of cables. Also suitable for processes requiring the delivery of a regulated amount of milled and molten materials for sheeting or coating purposes. There is a complete range of SHAW Extruders including laboratory models.



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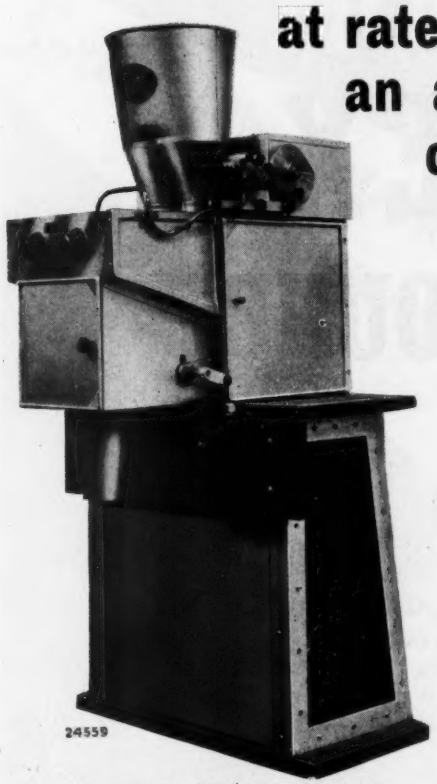
at rates up to sixteen per minute to an accuracy of half of one per cent of the weight required



OSBORN AUTOMATIC WEIGHING MACHINE (POWDER TYPE)

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This machine is made in two types—one for weighing chemical, metallic or plastic powders and pellets and the other for weighing screws, nuts, rivets, bolts, gramophone needles and similar articles.

Each type made in **four sizes,** 0 to 4 oz., 4 oz. to 1 lb., 1 lb. to 4 lb., and 4 lb. to 16 lb. Special sizes made to order.

Our specialists are always available to assist with your weighing problems.

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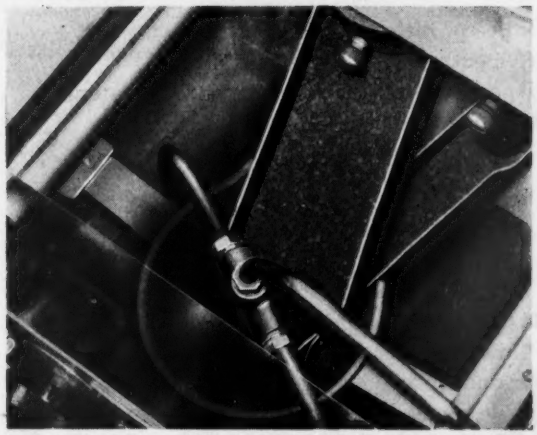

THE VIBRATORY FEED ARRANGEMENT SHOWING THE COARSE AND FINE FEED MECHANISM FOR WEIGHING PLASTIC POWDER.

A SIMILAR VIBRATORY FEED ARRANGEMENT USED FOR WEIGHING GRUB SCREWS.

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Vinatex Limited manufacture a complete range of Polyvinyl chloride compounds which can be supplied in the form of chips, slabs or uniform pellets.

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We make compounds for... Petrol resistant extrusions. Non-toxic extrusions. Rigid anti-shatter extrusions. Dielectric, direct insulation and sheathing purposes. High clarity extrusions. General purpose extrusions. Gramophone records.

In addition

We make polyvinyl chloride pastes, "Vinamold" hot melt compounds, "Vinagel" modelling and moulding materials and "Vinatex" Coated paper and cloth.

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IN LOW TEMPERATURE THERMOPLASTICS

Spray LOW TEMPERATURE MELTING NON-SHRINKING ALLOYS....

MAKES MOULDS FROM PATTERNS OF ANY MATERIAL

PERFECT REPRODUCTION

LOW PRODUCTION COST

100% METAL SALVAGE

NO POLISHING

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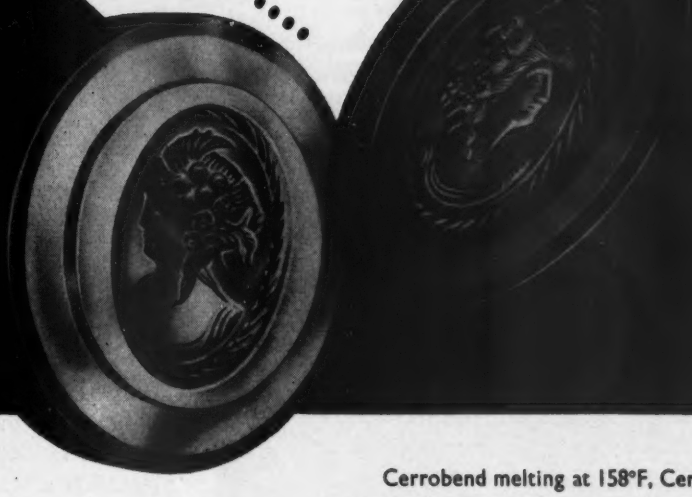

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Cerrobend melting at 158°F, Cerrobase at 255°F and Cerrotru at 281°F are easily sprayed against master models with inexpensive equipment. The resultant negative cavity, reproducing the finest detail, provides excellent mould for short runs in thermoplastics. After use moulds may be re-melted and metal fully recovered.

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Low-Temperature-Melting Non-Shrinking Alloys ALLOYS

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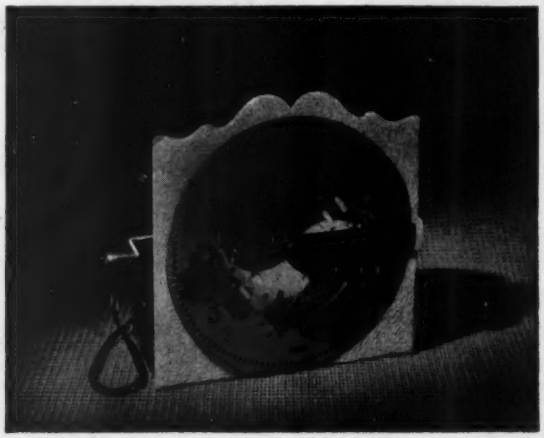
says Mr. Bessant of Universal Tools.

. . . to play the "SELCOL HURDY GURDY" and it needs no skill or experience and very little effort to produce a tune.

You can't make moulds however, by just turning a handle, it demands a vast amount of skill and experience plus some quite elaborate plant. Even then if you want to make really good tools, you've got to add a real interest in a customer's project and I'm sure it is just this combination which has enabled us to tool successfully so many of the "tricky" mouldings you see around.



Fifteen different plastic mouldings are used in this attractive and tuneful toy, moulded by Thames Valley Moulders, Ltd., for Selcol Products, Ltd., on Peco 8-oz. injection machines.

It has a realistic tone and a repertoire of tunes is provided by means of the rapidly changed paper disc records.

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motor, the power being transmitted
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- adjustment of working speed, ratio 1:10, and of friction ratio from 1:1 up to 1,5:1,
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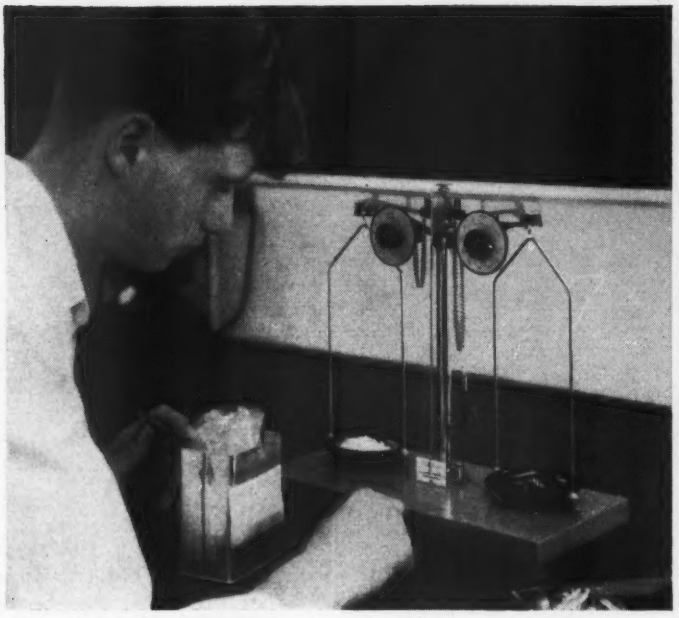


1 *Weighing dye for Colourant Blend mixing.*

2 *Filling drum tumbler with Colourant Blend.*

The LUSTREX* Dry Colouri

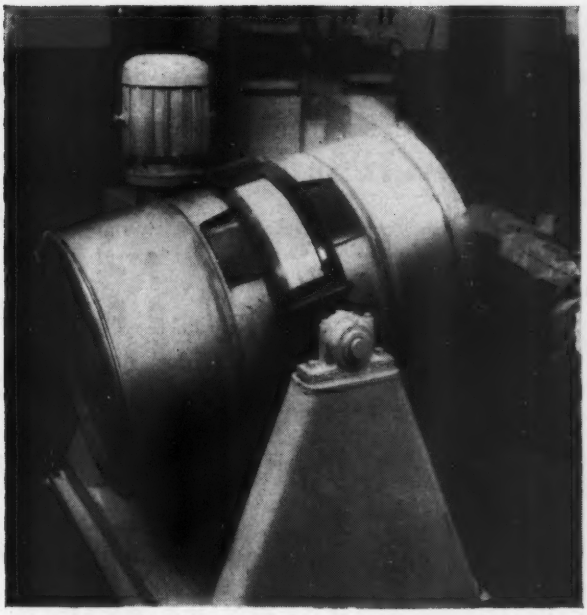
A simple, economical method of colo
polystyrene to any shade you

THE economic advantages of Monsanto's Lustrex Colourant
are being more and more widely appreciated in the industry
the advent of this versatile form of polysty
The outstanding virtue of Lustrex Colourant Blend is the extreme simp
with which it can be used in the dry colouring process. The only extra equip
required is a simple drum tumbler which will handle a charge of 50-150 lbs. of polysty
and a balance on which the dyes can be weighed. Processing is easy. After m
under controlled conditions, the dyestuff adheres uniformly to the surfa
the Colourant Blend granules. The material can then be removed an
directly into the injection moulding ma
Our series of illustrations shows these operations, step by

But simplicity is not the only attraction of Lustrex Colourant
Consider these points, t

Colouring costs are so low that savings of many pence per lb. can be compared with coloured moulding powders. Colourant Blend is supp exactly the same price as Lustrex general moulding grade crystal. Any can be produced at short notice. This permits greater flexibility of ope

ling dye to Colourant Blend in drum tumbler.

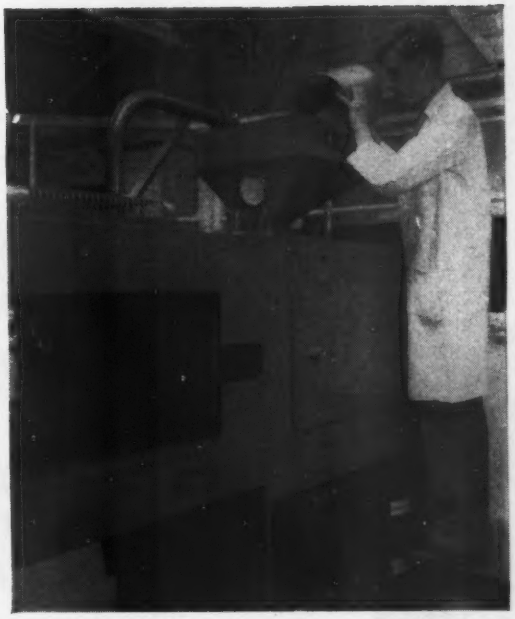


4 *Drum tumbler in operation.*

rirocess

a comparatively small stock of crystal need be carried uce all the shades desired. Leading moulders in the have found it possible to reduce stocks by as 75%.

the use of Lustrex Colourant Blend, it is now to produce — at reduced cost — a wide range of velties, houseware and miscellaneous articles which eviously moulded from processed colours.



5 *Charging the injection moulding-machine hopper with Colourant Blend.*

ation. Full details and technical information from Sales Department, Monsanto Chemicals Limited, l also be pleased to tell you about the many other ls and plastics for your industry. These include: Cresylic Acids, Aroclors*.

*(*Aroclor and Lustrex are Registered Trade Marks)*

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Turns P.V.C. into products

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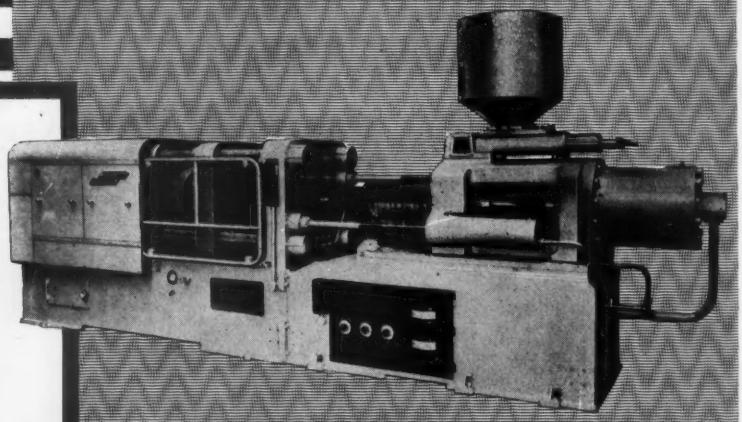
facts

that speak for themselves

"SUNNYCAGE" BIRD CAGE

WEIGHT—500 grams each half of cage (the cage is moulded in two identical sections from one tool and chemically welded).
MATERIAL - Polystyrene
TIME - - 25 per hour
Moulding by EKCO Plastics Division for and to the design of "Sunnytoys" (Distributors) Ltd., of Blackpool.
Mould designed and made by EKCO Plastic Division.



The design and proved performance of PECO Injection Moulding Machines result in the production of plastic articles of the widest range, from simple domestic goods to intricate mouldings such as this Bird Cage illustrated. Always these machines give the same perfect, undeviating production flow. Do you ask for impartial recommendation? It comes from the manufacturers all over the world who have installed them.

Illustrated literature describing the full range of PECO machines will be sent on request.

MOULDS

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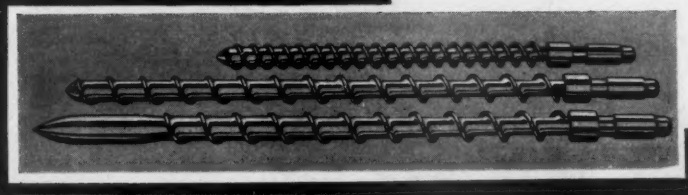
PECO enters the field of

EXTRUSION

'PECO' 2½" EXTRUDER



Left:
3 Typical Standard Screws

PECO PRODUCTS

THE PROJECTILE & ENGINEERING COMPANY LTD

TOYS CAN BE DANGEROUS!

If you are a manufacturer, ask the moulding powder producer for powders made from 'Celanese' Acetate Flake. Acetate means fewer breakages in production and in transit; it means better, **safer** toys. If you are a retailer, ask your supplier for toys made from Acetate. Safety is always a sure seller and Acetate is shatterproof, splinterproof and tough—tough enough to make selling easy. Play **safe** with Acetate!

Make sure your toys are made from

'Celanese' TRADE MARK *Acetate Flake*

They're safer, tougher and more hygienic

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We are not making bullets . . .

. . . for the Defence Programme. But we are producing injection mouldings for many of the allied industries—Radar, Radio, Electrical, Automobile, Aeronautical, Marine, etc., etc. (some recent productions are shown here).

We are specialists in technical mouldings up to 16 ozs. in the usual thermo-plastic materials.

Our planning Department, Technical and Advisory Staff are at your service.

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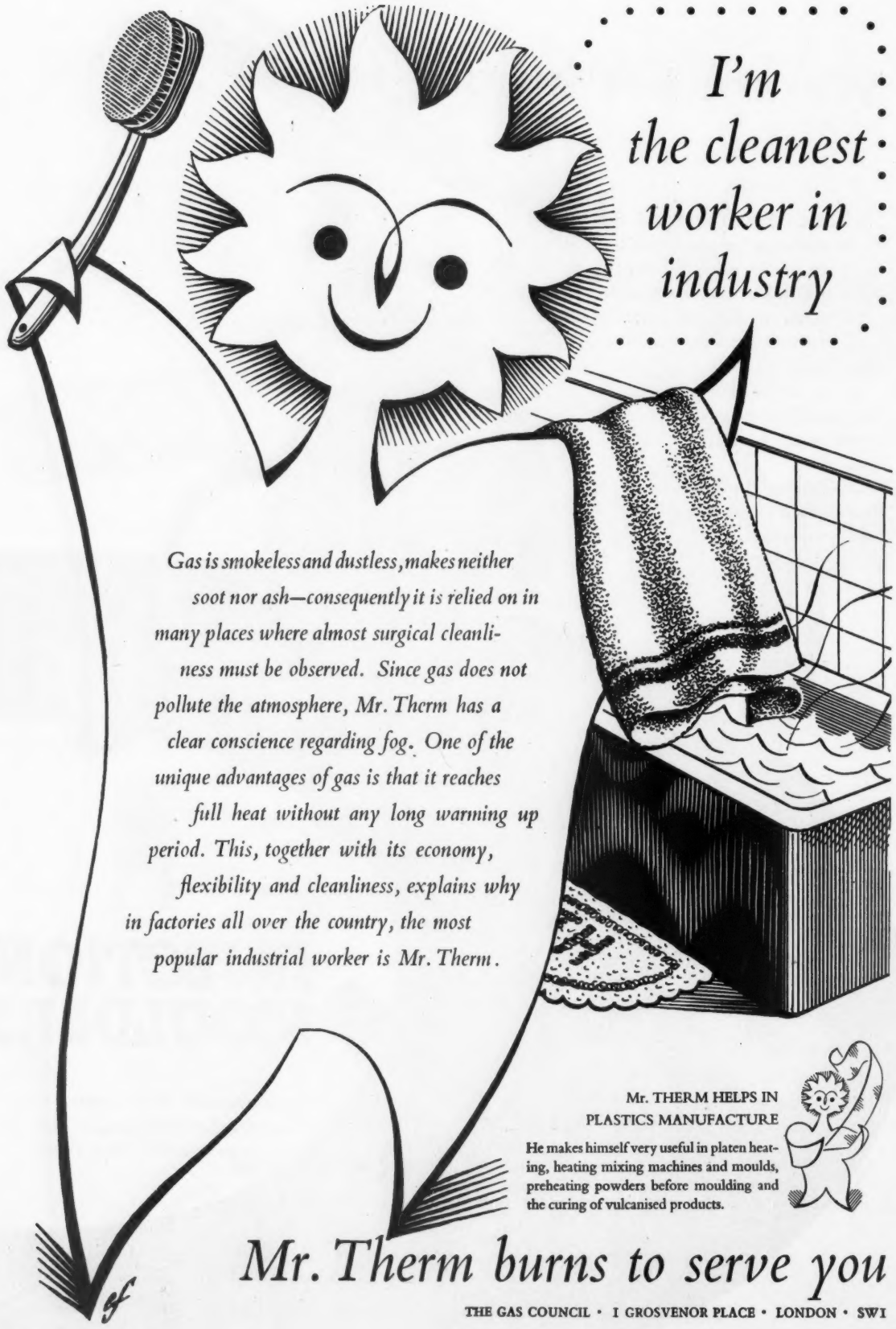
Telephone: COLindale 8868/9, 8860
Grams: Injecmould, Hyde, London

IM 14



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Gas is smokeless and dustless, makes neither soot nor ash—consequently it is relied on in many places where almost surgical cleanliness must be observed. Since gas does not pollute the atmosphere, Mr. Therm has a clear conscience regarding fog. One of the unique advantages of gas is that it reaches full heat without any long warming up period. This, together with its economy, flexibility and cleanliness, explains why in factories all over the country, the most popular industrial worker is Mr. Therm.

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Let British Visqueen Ltd., put you in touch with 'VISQUEEN' converters who will solve your packaging problems and give you new ideas to sell your products.

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'Visqueen' film is all polythene, but not all polythene film is 'Visqueen'.

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Turn your plastic scrap into cash
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★ **POLYETHYLENE** ★ **ACRYLIC**

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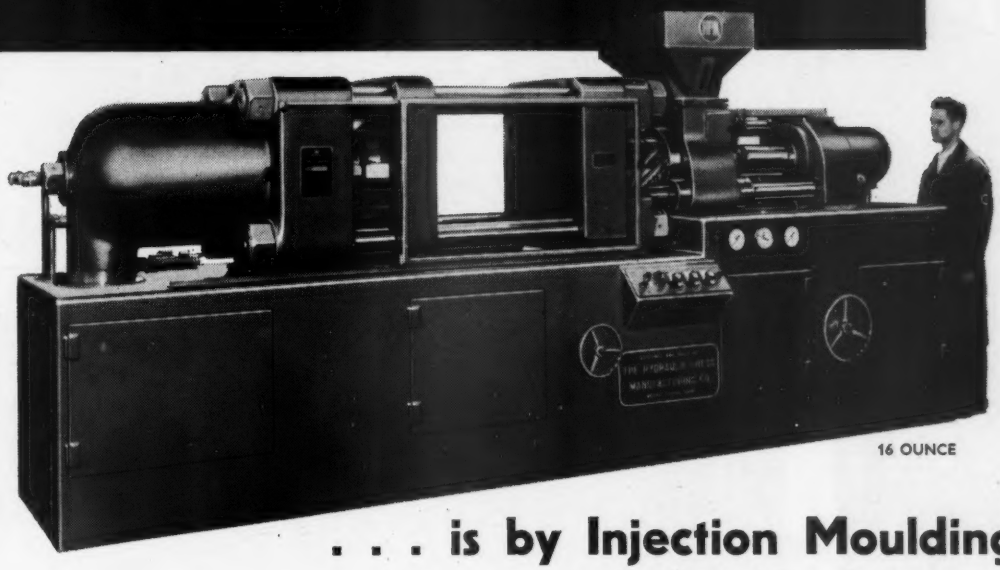
The fastest and cheapest way to make thermo-plastic parts



16 OUNCE

. . . is by Injection Moulding on H.P.M. Equipment

Here's why

FAST MOULDING CYCLE
Injection moulding is the fastest method of producing thermo-plastic parts and H.P.M.'s are the fastest moulders in the industry.

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The H.P.M. straight-line hydraulic mould clamp permits moulds to be interchanged in a minimum of time. No adjustment is required for moulds of different thicknesses.

VERSATILE APPLICATION
Hydraulic controls provide easy and quick method of adjustment for speed and pressure. This means universal application with a wide range of injection capacities.

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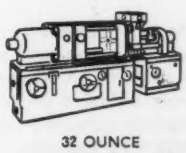
A MACHINE TO SUIT YOUR JOB
There's an H.P.M. Injection Machine for every moulding need—9, 16, 32 and 60 ounces per cycle.

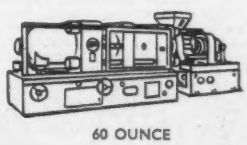
HPM

9 OUNCE

16 OUNCE



32 OUNCE



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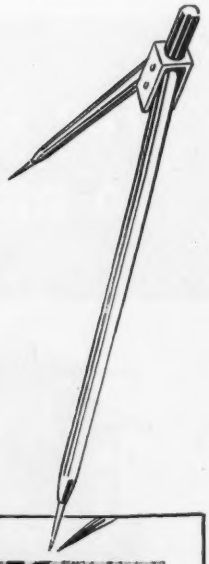
Planning must come first.....



"To plan" is to arrange beforehand and "To consult" is to seek advice from. All plans have their problems and it is advisable to consult us in the early stages of considering your problem so that an individually engineered installation may be supplied to fulfil your specific requirements. We have facilities to advise on any drying problem whether it is for a new installation or an adaptation to existing ancillary equipment.

By courtesy of Nelsons Acetate Ltd.

Materials now being processed include:—

Alginic Acid, Almonds, Aluminium Swarf, Ammonium Chloride, Ammonium Nitrate, Amino-Thiazole, Apple Pomace, Beet Sugar, Bicarbonate of Soda, Bones (degelatinised), Bone Meal, Bran, Brass Swarf, Breadcrumbs, Calcium Alginate, Calcium Citrate, Calcium Hypochlor, Carbon Black, Carburising Material, Cellulose Acetate, Cellulose Chips, Cement Clinker, Cereals, Cocoa Nibs and Beans, Coffee Beans (Roasted), Flaked Maize, Foundry Core Sand, Fullers Earth, Grain, Grainer Salt, Graphite, Gravel Sand, Gravy Powder, Ground Copra, Ground Mica, Peanuts in Shell, Peanut Kernels, Pea-pods, Peat, Potash Crystals, Potassium Bichromate, Potassium Perchlorate, Puffed Wheat and Rice, Pumice, Pyrites, Salt, Saltpetre Sawmill Refuse, Sawdust, Seaweed, Sewage Sludge, Seed Corn, Silica Sand, Sludge, Soda Crystals, Soap Flakes, Sodium Acetate, Sodium Nitrate, Sodium Bichromate, Sodium Florcyanide, Sodium Sulphate, Sorbose Sphagnum, Salt (Medicinal), Soya Bean Meal, Starch, Sugar (Cane), Sugar (Confectioners), Sulphate of Ammonia, Sulphanite Press Cake, Wheat (Cooked), Wood Chips.

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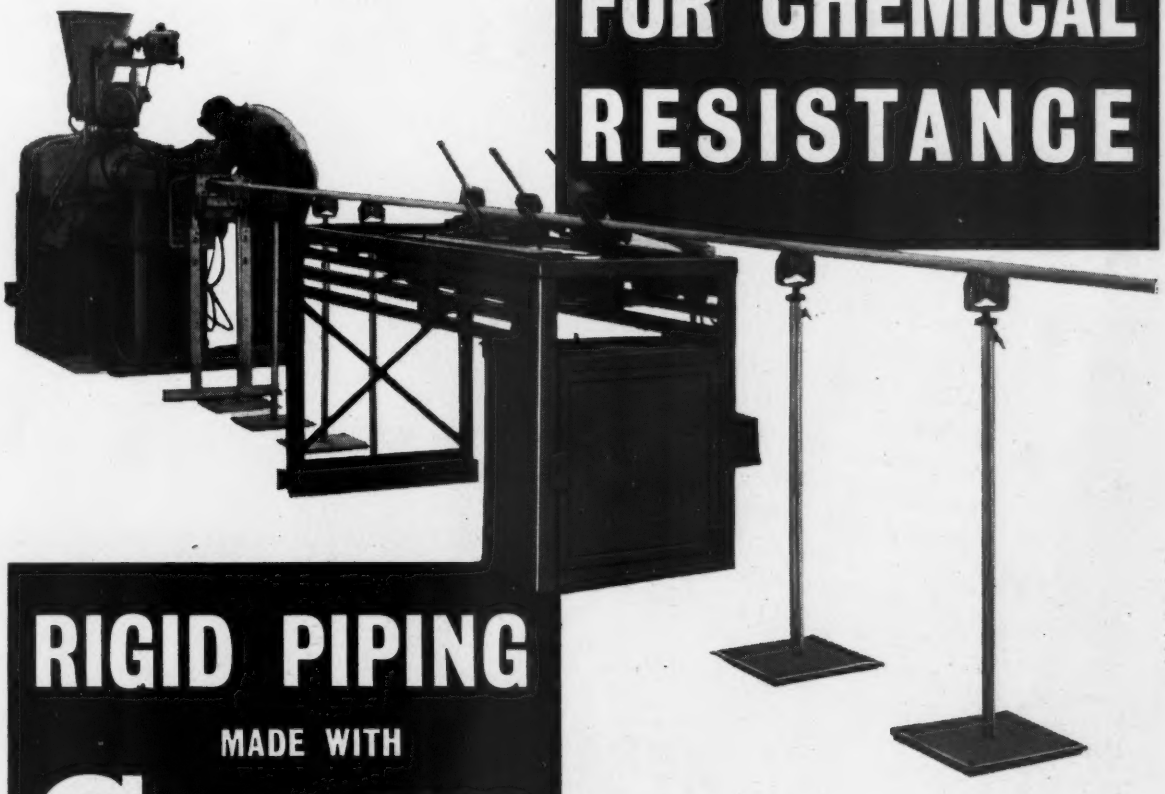

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Please write for Booklet No. 51, *describing the Geon range of PVC raw materials.*

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Geon Polyvinyl Materials

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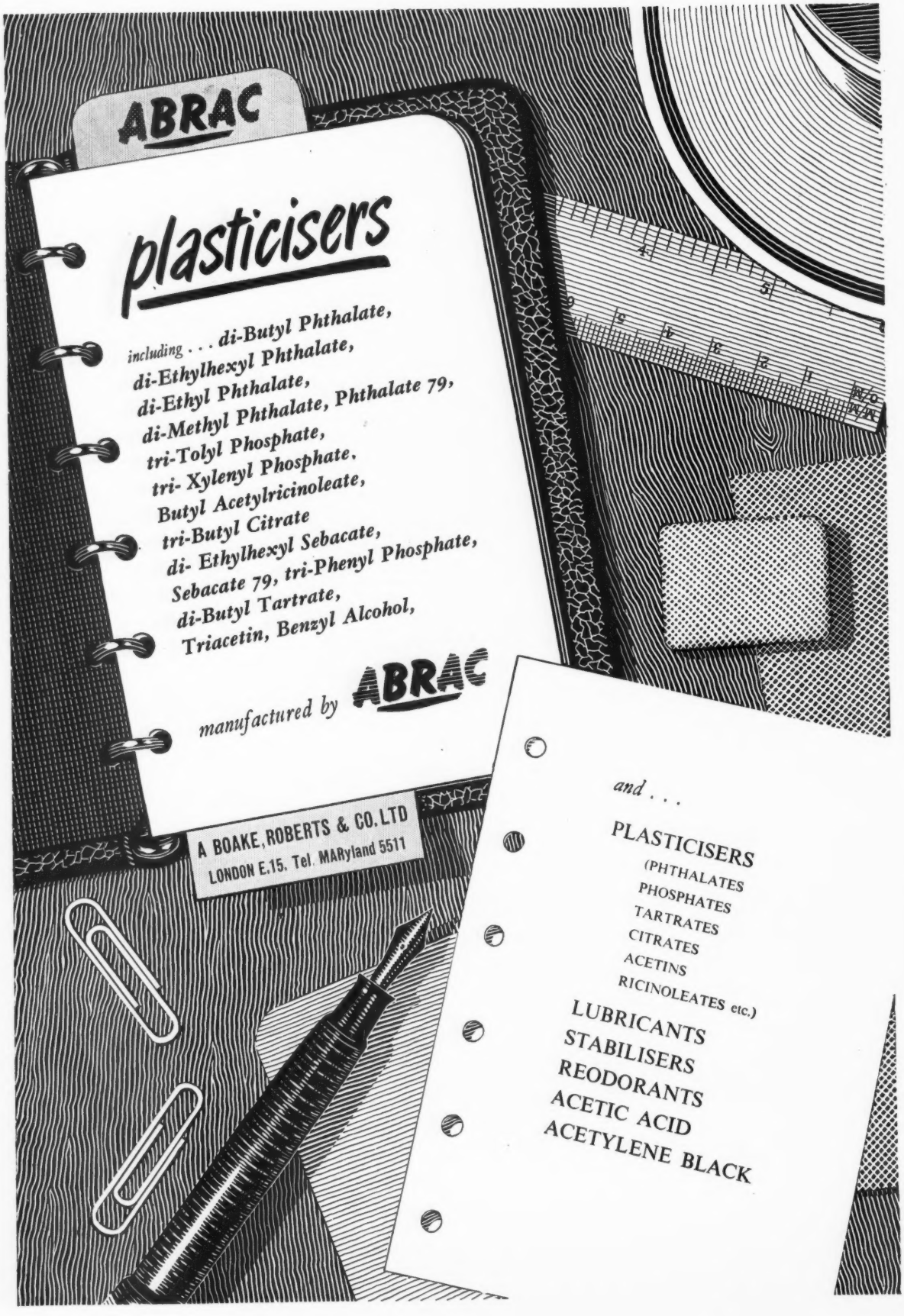
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tri-Tolyl Phosphate,
tri- Xylenyl Phosphate,
Butyl Acetylricinoleate,
tri-Butyl Citrate
di- Ethylhexyl Sebacate,
Sebacate 79, tri-Phenyl Phosphate,
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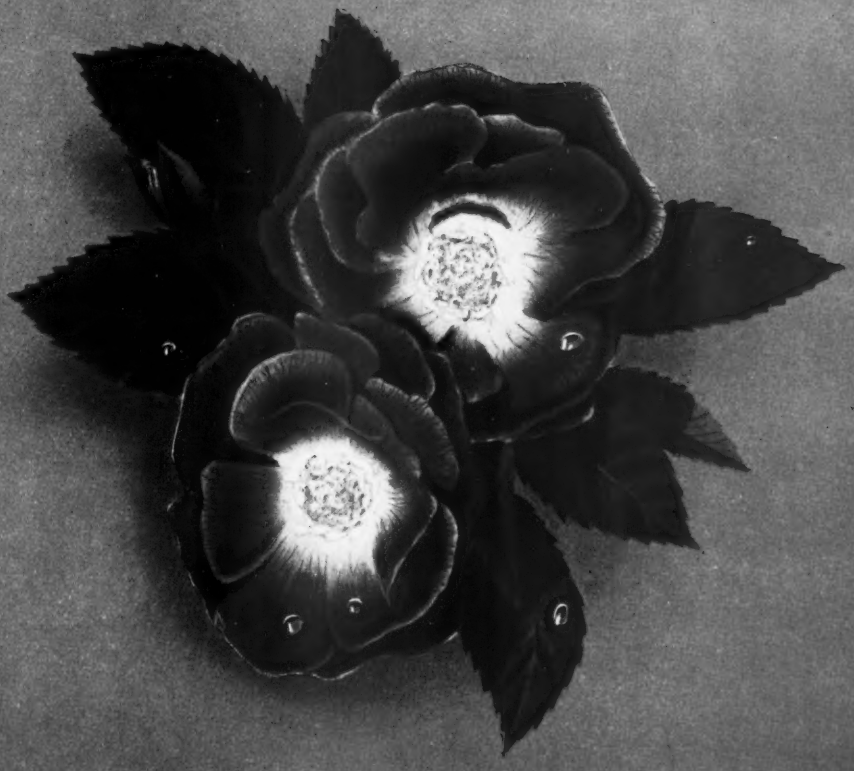
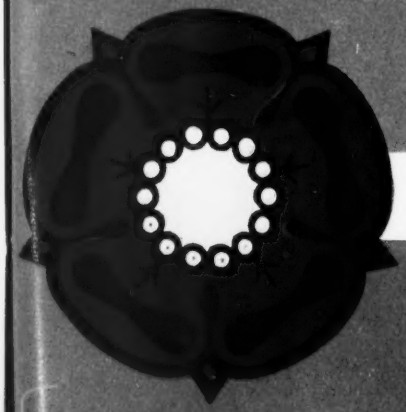
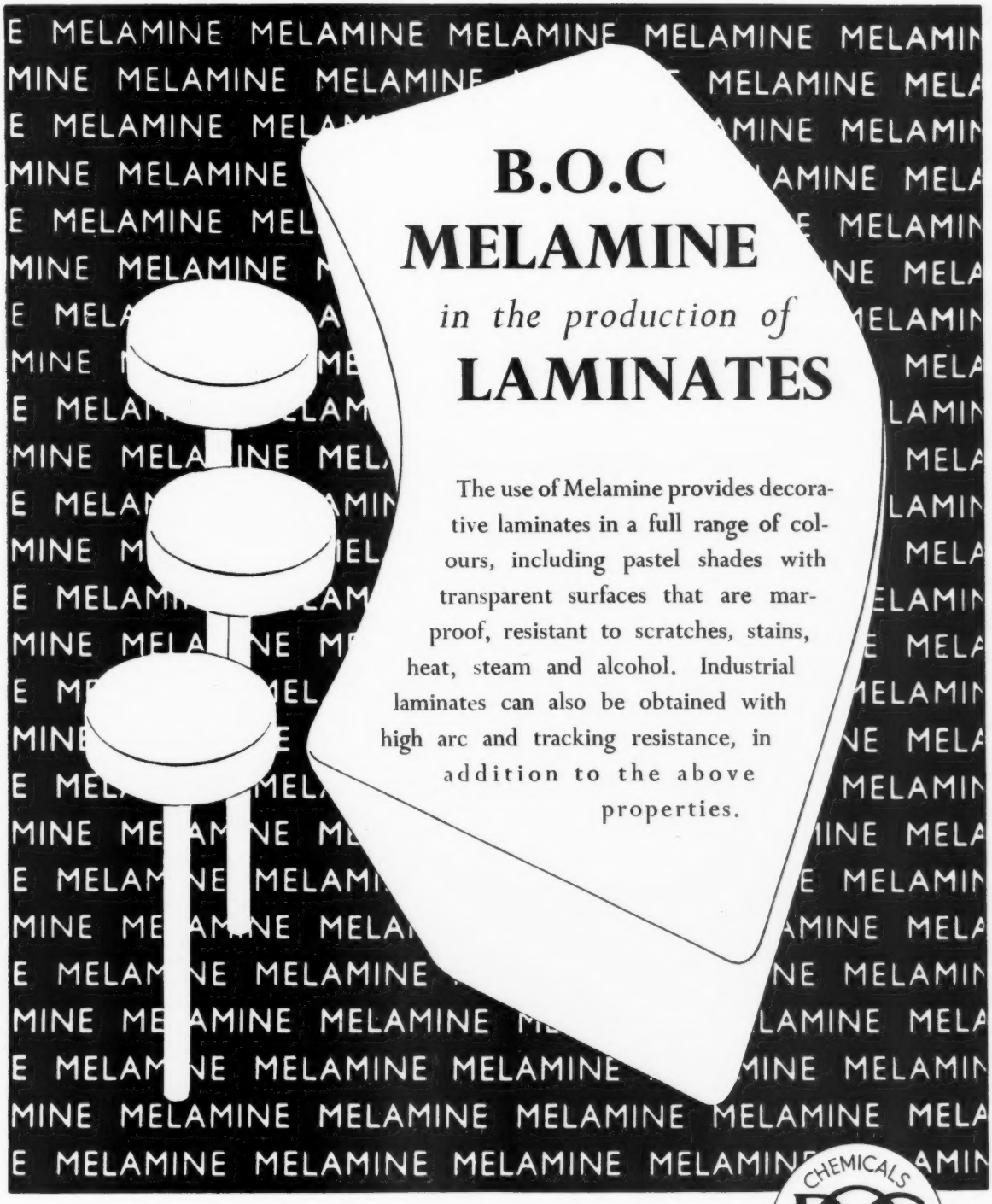


About 1277, Henry III's son, Egmond the first Earl of Lancaster, returned from France with the red rose of Provins as his badge, and so originated Lancashire's well-known emblem. It is not certain whether Egmond was inspired by the species Rosa Damascena or Rosa Gallica, as both were grown in Provins at that time. We have chosen the latter as our illustration, as its French name seems more appropriate.

As a humble symbol of the later unity of the Houses of York and Lancaster, the Elo factories in these two counties at Liversedge and Wythenshaw combine their experience, facilities and resources in the service of plastics users throughout the world, and together, through the Directors and Staff of Birkbys Ltd., send sincere wishes to all for a Happy Christmas and a Bright New Year.



Christmas Greetings from Birkbys Ltd.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- 3,700 ton Multi-daylight Press, platens 9′ x 4′ with self-contained Pumping Equipment.
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ILLUSTRATED: LIGHTING TROUGH MOULDED IN ONE OPERATION

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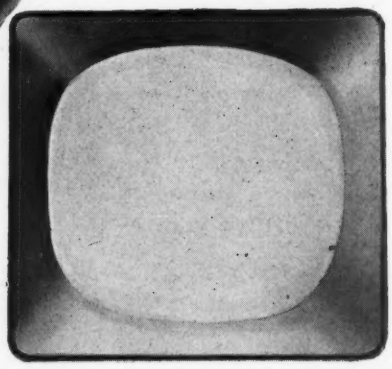

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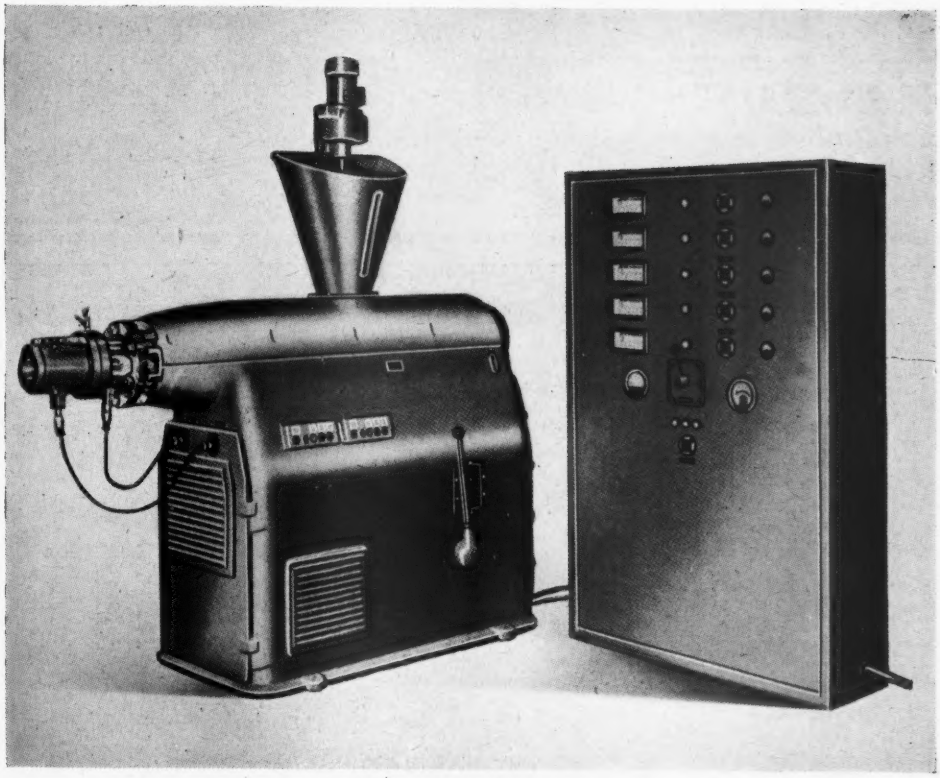

3½" EXTRUDER

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Most of the leading British and American Moulding Machines are fitted exclusively with

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FOR THE AUTOMATIC CONTROL OF INJECTION MOULDING MACHINE NOZZLE TEMPERATURES

The "Capacitrol" controls electrically heated nozzle temperatures with the greatest speed and accuracy possible with any such apparatus. It is electronically operated, reliable, moderate in price and has greater accuracy than the mechanically operated type.

The "CAPACITROL" (EW 221) TEMPERATURE CONTROLLER

This instrument is fitted as standard to the E.M.B. Machine illustrated.

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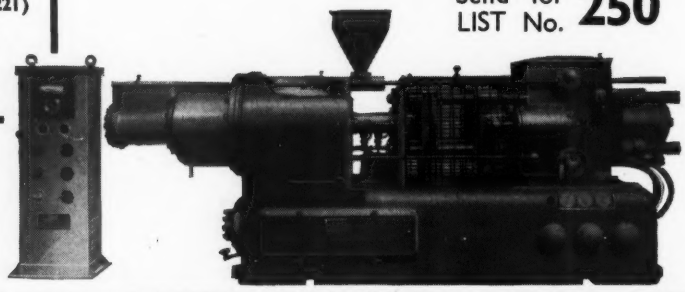

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Acidity as acetic acid: 0.0005% by wt. maximum.
Permanganate fading time: more than six hours.

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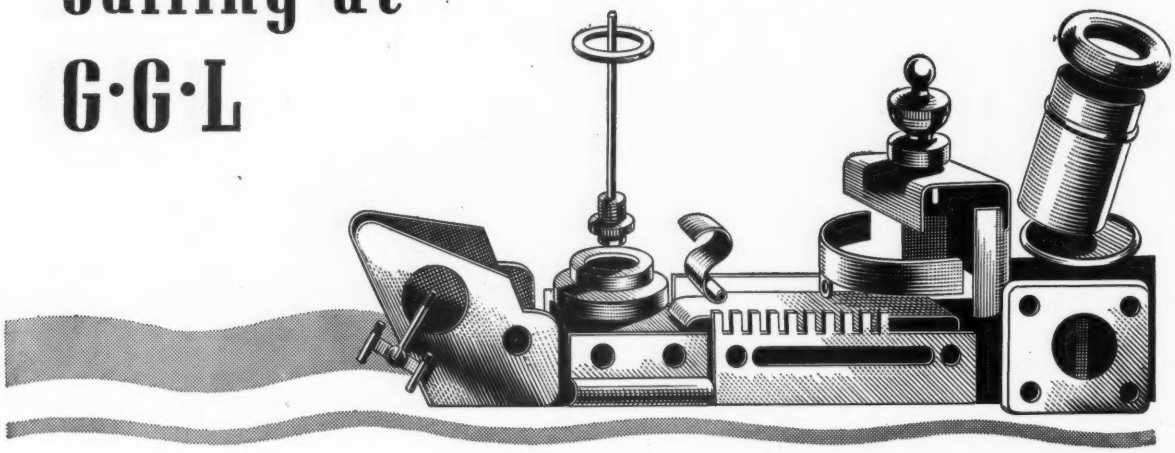

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The outstanding combination of mechanical strength, chemical resistance and electrical properties makes Vitrathene sheet a valuable addition to industrial materials—especially for the chemical industry. Vitrathene is also an ideal material for Surgical Splints and Jackets.

Available in Sheets size 36″ × 36″ and 84″ × 36″ and Rods, Tubes and Blocks.

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is tough, resistant to chemical attack and non-inflammable. It is an easily formed material and ideal for :—

Refrigerators,
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Available in various sheet sizes with mirror finish and matt surfaces in thicknesses from ·010″ upwards. Also Sheets size 96″ × 36″ in thicknesses from 1/32″ upwards. *Calendered and Rigid Foil.*

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have pleasure in announcing that they have been appointed sole agents in the United Kingdom for

PASQUETTI EXTRUDERS

manufactured at Varese, Italy, for producing moulding powder granules, rods, tubes and various shapes and sections in plastic materials.

Illustrated on the right is the patented twin screw Pasquetti Extruder.

Nominal capacity : 8 - 40½ lbs. per hour (depending on material and type of extrusion).

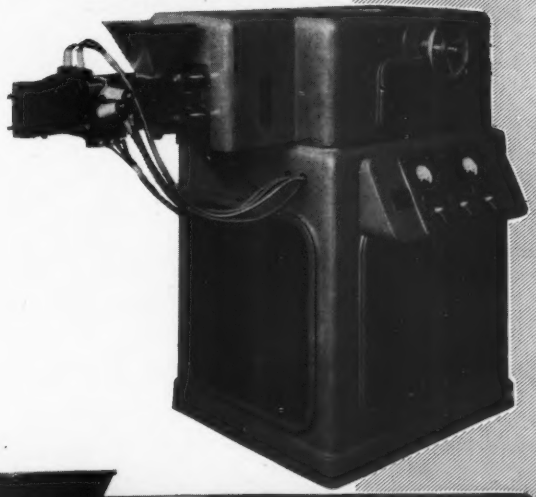
Motor : 1.6 h.p. Fitted with protected starter and overload release.

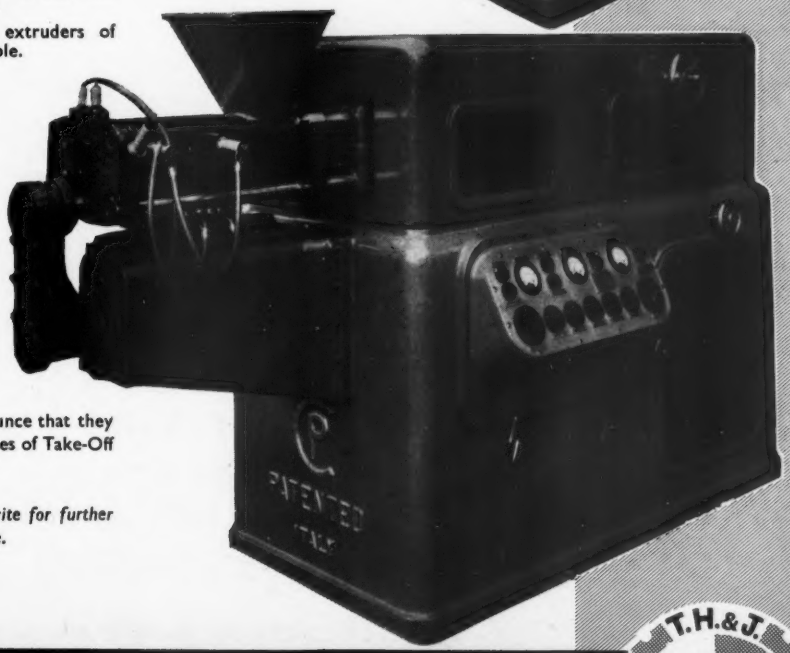
Electrical heating : 0.8 kws.

Screws : Two 1⅞" diameter. Hardened nickel-chrome steel screws, each in two sections having four and two starts respectively.

Illustrated below is a much larger model with a capacity of 44-133 lbs. per hour (depending on material and extrusion) and with two 3" diameter screws.

Patented bi-helicoidal gear extruders of larger capacity are also available.





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You are cordially invited to write for further details and illustrated literature.

T.H. & J. DANIELS LTD.

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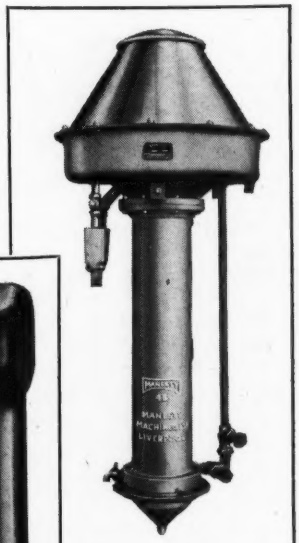
MANESTY

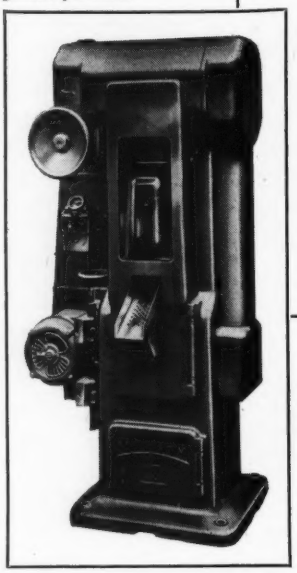
MACHINES and EQUIPMENT

By installing MANESTY Machines and Equipment, plastics manufacturers at home and abroad have been able to obtain greater production efficiency with reduced costs. For preforming processes, MANESTY Pelleting Presses — with their extreme versatility, reliability and ease of operation — ensure a striking increase in the output of preforms. When distilled water is required, a MANESTY Automatic Water Still is by far the simplest method of providing it, eliminating all handling and storage problems and giving a constant, immediate supply of fresh, pure distilled water at negligible cost. MANESTY Stills, operated by gas, electricity, steam or paraffin, range in output from 2 pints to 50 gallons per hour. Many models are now available in the new chrome vitreous finish. Other MANESTY Machines and Equipment include coating pans, granulators, mixers and punches and dies.

Write TO-DAY for illustrated leaflets



Right: The Manesty 4B Automatic Water Still. Steam heated. Output: 50 *gallons per hour.*



Left: The new Manesty 3A Preforming Press. Single or multi-punch. Variable speed drive. Output: 16 - 256 *pellets per minute; max. diam.* 2¼".

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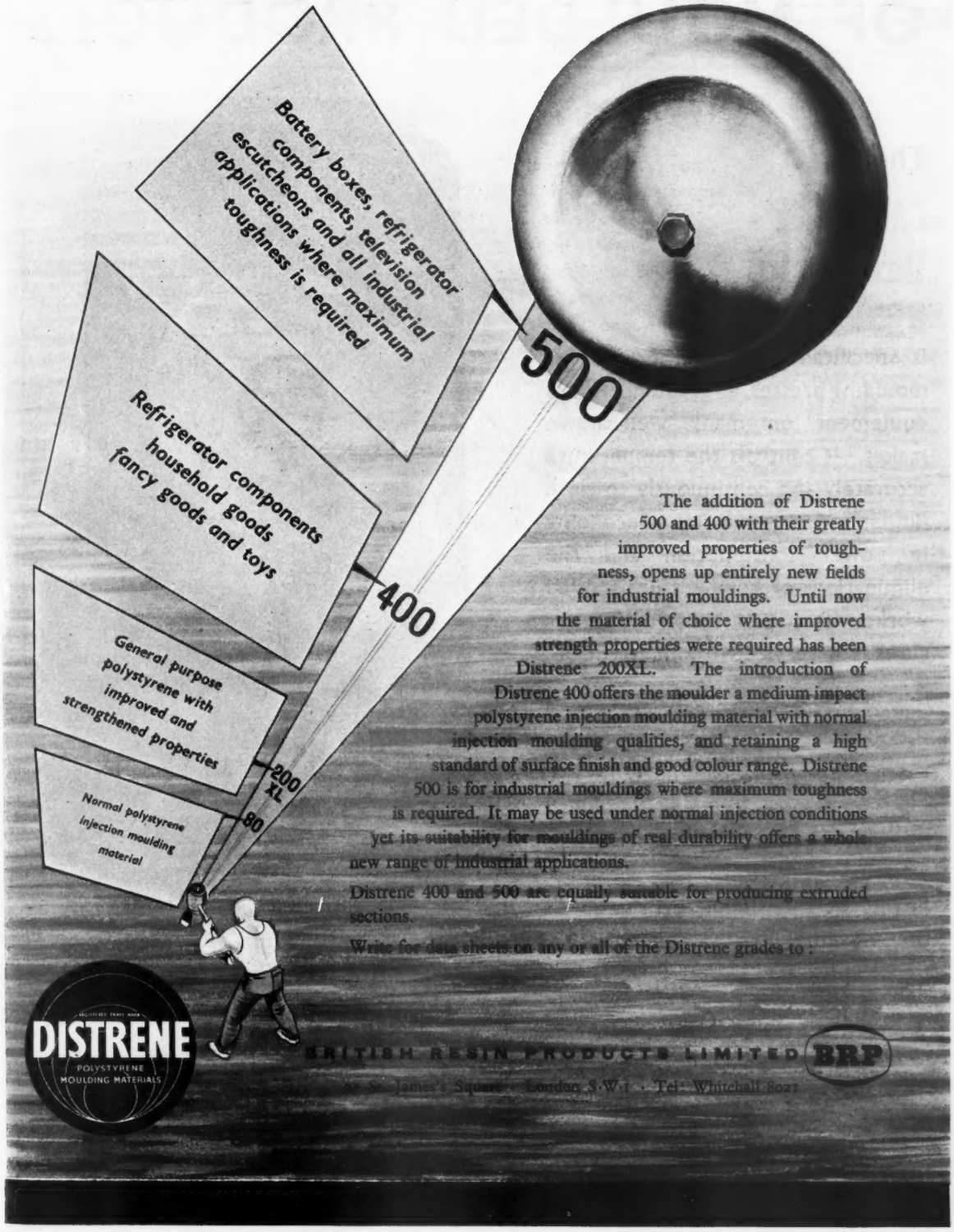
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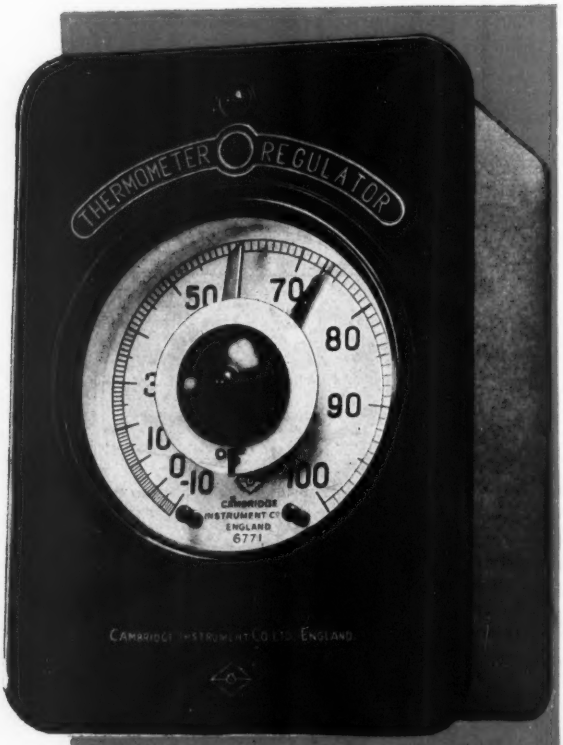

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Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIALS

PROPRIETORS: TEMPLE PRESS LIMITED

CHAIRMAN and MANAGING DIRECTOR: ROLAND E. DANGERFIELD

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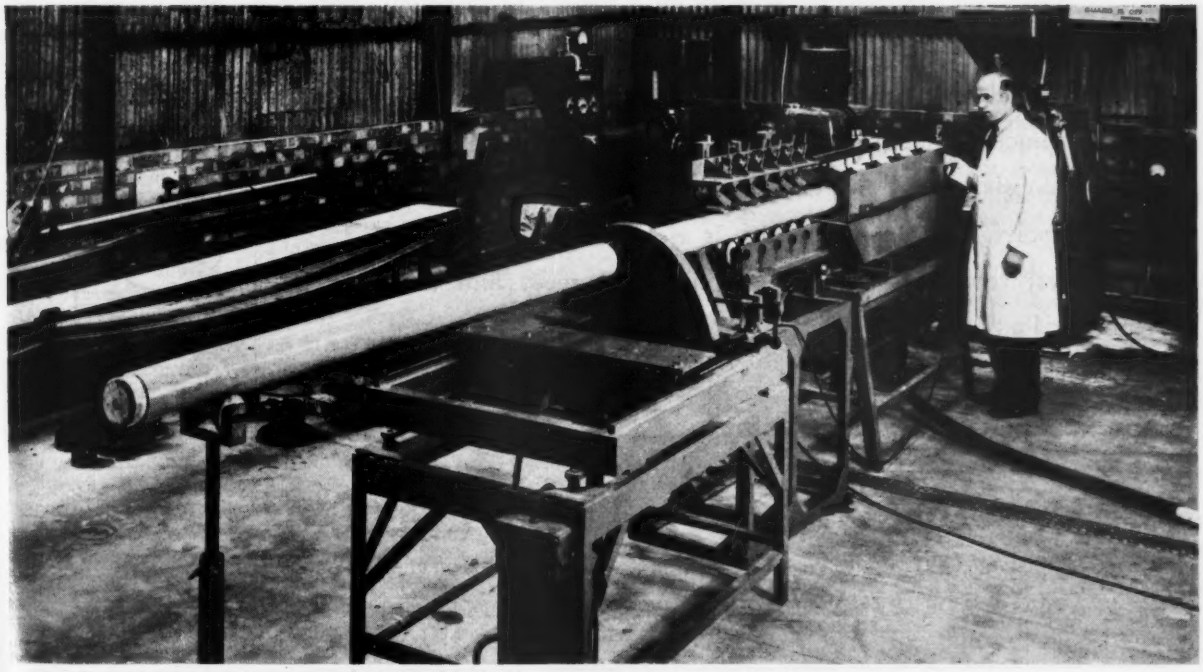
Extrusion of rigid unplasticized polyvinyl chloride tube at Erinoid, Ltd., Stroud, Glos.



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Plastics

VOL. XVIII. No. 197 DECEMBER, 1953

EDITORIALS

Extrusion

THIS month's issue of *Plastics* is devoted almost in its entirety to the history and technical development of the extrusion of plastic materials, a growing section of the plastics industry producing continuous lengths of uniform profiles or cross-sections. The greater proportion of the raw materials employed are thermoplastic in character.

While in basic principles the mechanical process of extrusion has not changed since 1880, improvements have been great, the most spectacular being the discovery and production after the first quarter of the 20th century of the first of the completely synthetic, "man-made" polymers from carbide, coal tar and petroleum, as opposed to those plastic materials derived from the natural compounds, cotton and casein. It is due, in large part, to the great chemical difference between the two types that the modern extrusion industry has been able so to widen its sphere of action and application that it bears now but little resemblance to the older endeavour.

The story we unfold is, in the main, devised to show the industrial, technical and general reader outside the plastics industry, in other words the potential user of extruded plastics, something of the structure of a section that had grown slowly up to the early 1940s, but that has gained considerable impetus since that date, something of its raw materials, their compounding and their differences, and why each difference may often be important enough to give it preference for a particular application, whether it is in the technical or more general field.

This special issue describes also the modern machinery of the industry which, while it is directly derived from that of the rubber industry of the 1880s, nevertheless possesses important and distinct differences because of the wide divergence in physical characteristics between rubber and plastics. In general structure, the plastics extruding factory may, from one point of view, be considered simpler than its forerunner since it is not tied down to the mixing plant and calendering machines which constitute so important and costly part of the rubber extrusion process—the extruder of plastics receives his raw material completely ready for extrusion in his machines. His work is thus simplified so far as the economics of his factory are concerned. On the other hand, his machines are more complex and refined to take charge of a much wider variety of raw materials, each of which must be worked under different conditions.

Again, the story displays what will interest the outside world most—the multitudinous array of applications for an equally wide range of industries. The observant, as a result, will be aware of the reason for their creation and acceptance—often replacing materials long in use by tradition, often carving new paths because of their specific properties—conditions which are, or should be, the reason for acceptance of plastics produced by any process.

We are glad to publish on the opening page of this special issue a message from Mr. Donal Sullivan, whose practical work in this branch has proved so effective and whose labours in the appropriate section of the British Plastics Federation has guided its members towards the attainment of high-quality products.

Finally, we wish to thank all those individuals, the raw material manufacturers, the machine makers and the extruding companies who have aided in the construction of what follows, by the writing of special articles, supplying valuable data to evaluate and distinguish their products, or by sending us actual samples of extruded units for photography or for making sectional drawings.

The special number is obviously not complete, but we trust that here we have more than the bare bones of the subject. We are fairly sure, so rapid will be the growth, that we can confidently look forward to a re-examination of the extrusion industry in another few years.

Technical Research

DURING the early days of extrusion of the then newer polymers it was a matter of compounding a given plastic material so that it could be worked on the few comparatively elementary type of machines then available, rather than making special machines for the job. Then, little was known about the physical and chemical characteristics of plastics in the "fluid" form they assume under temperature and pressure, since they behave very differently from the "simple" fluids we normally encounter and which are termed Newtonian fluids. We are dealing with substances composed of giant molecules of high viscosity and whose properties of very poor conductivity of heat, general absence of sharp melting point and other characteristics are facts which make design and close control of the extruding machine of exceptional importance.

Today the physical understanding of these materials is considerable although still far from complete, and a great deal is known about the most appropriate conditions for the extrusion of different types. It may at once be said that much of the technical research in this field has been carried out by the raw material manufacturers and has been rapidly translated into effect by the modern extrusion machine engineers—the new machine is built so that almost any type of existing plastic material may, with suitable adjustment, be worked thereon. What is also most encouraging is that machine makers are now launching their own schemes of research, a movement which cannot but bear good fruit.

New "Vinyl" Plant

FIVE years ago we went to Aycliffe, County Durham, to visit a new factory erected by Bakelite, Ltd.; we saw therein what must be one of the most modern of "phenolic" and "urea" resin plants. It displayed in no uncertain manner the advances in chemical engineering made since the early 1920s, the "clean flow sheet," smooth production and the higher quality of products resulting therefrom.

During our visit we also saw the very beginnings of a different type of plant for the production of a new thermoplastic material which represented a distinct departure for the company, whose history has always revolved round the thermosetting moulding compounds. It was a conception based on the certainty of the opening-up of new fields of application for thermoplastics.

On November 24, we visited Aycliffe a second time and

saw the new plant in active production. It can clearly compare in design and execution with any other in the world and produces for the first time in this country a copolymer of vinyl chloride and vinyl acetate, hitherto imported into this country from the U.S.A. When in full production the factory will yield some 5,000 tons per annum and will thus save the country its equivalent in dollar expenditure.

In our January issue we shall describe in greater detail and illustrate by photographs this £1,000,000 plant of which the company, and the country, may justly be proud.

MOULDING POWDER AND SHOT

Salad Conscious World

More letters have been sent to me from plastics moulders and agents regarding my two previous notes on the polythene injection moulded salad drier I picked up in France. Some of them came from afar—the U.S.A., Italy and Yugoslavia—all want to make or import them and ask me to send samples and/or quotations p.d.q. I'd love to help, but I picked it up in a "Uniprix" ("Woolworth's" and "Littlewood's" are our equivalents) and I won't be going over again for many months. Besides I haven't any quotation forms printed and I wouldn't know how to fill them up if I had them. I strongly advise readers who are interested to pop over to Paris for an hour or so and get a sample themselves.

◆ ◆ ◆

Rest In Plastics

When my uncle L.(S.)D., the well-known pen-and-ink artist, passed on greatly to the regret of three persons, my Aunt Gwen, who during the previous 25 years had only seen him for four of them (he worked apparently on the Biblical Jacobean principle of seven-year stretches) nevertheless possessed a fine sense of the proprieties and asked me to conceive some sort of memorial to him. I had at the time as a bedside book, Ambrose Bierce's "My Favourite Murder," and the author's touching reference to, and love for, his own uncle reminded me that after all, blood is thicker than something or other. Whereupon, after the usual formalities, his ashes came to me. These I mixed with 50% phenolic resin moulding material of the highest quality and moulded from it a dozen or so simple but dignified-looking ash-trays. No fancy stuff you know—just dignified. Each was engraved with the words: *You who stub your cigarette here on his ashes, remember Lancelot (Slush) Dogsboddy, one-time known as The Penman. He wrote, and having writ, passed them on.* We sent three off to high Governmental Officials—we found their names in his diary heavily underlined in red marked with large black spots —one to a place in Devonshire, one to the Isle of Wight and the third to an island called Alkathene (?) or Alkali (?) or some such name, off the west coast of the U.S.A. Three others we sent to old cronies, the licensee of "The Crooked Billet" and two individuals with the amusing names of Harry the Lag and Joe the Barman. The first three recipients may have "passed on" too, as we reverently say in these parts, for we had no acknowledgements whatsoever from them. The last named were very amiable, called to pay their deepest respects, and even gave me a five-pound note as token of their good wishes. I keep it to this day though I have been told that, strictly speaking, it is not legal tender. It was all very agreeable. This lengthy preamble (it happened so long ago that I may have dreamed it all) to acquaint you of my interest and indeed of my pleasure at learning recently from British Patent No. 696854 that a Mr. Douce had approached the problem of memorials to deceased persons in a much more knowledgeable manner and on a wider scale. By his methods he claims the production (by the incorporation of such ashes in plaster, cement and synthetic plastic) of ornamental or utilitarian objects for keeping in the home or for personal wear which can be distributed amongst the heirs of the deceased persons. He has even included the idea of embedding the ashes in a transparent bonding agent so that they may be visible: we presume that cast phenolics, polymethyl methacrylate and the polyesters may be employed. If I may say so, and if I remember my ablative absolute correctly: *Te duce, Douce, hostes vincemus,* which I shall translate as: "With you for leader, sweet Douce, we shall conquer the Last Enemy."

◆ ◆ ◆

It was a Dog's Life

As this December issue appears to be a very special issue on extrusion I feel I ought to contribute something to it from my own vast store of knowledge of the subject—something from the historical point of view—an idea which I hope will never be used again, but must have been one of the earliest of production jobs. I note that Simonds, Weith and Schack in their book on "Extrusion of Plastics" give the date of the first extrusions of polythene as 1941. It was, I feel sure, 1939, for in December of that year, exactly 14 years ago, I published the following note. I had received, presumably from a friend at I.C.I., an extruded tube of polythene, and as I was in the habit of giving my little black Scottie a nightly run round the perimeter of Lord's Cricket Ground during the black-out and losing sight of him every few minutes, I had the idea of painting the inner surface with luminous paint and tying a length round his neck. It worked like a charm. I never lost him and to his delight he scared other human beings stiff. On the other hand, his own lady-friends bolted in fright at the sight of the disembodied ring of light moving about nine inches from the ground and he never quite forgave me for it. Anyway, I published the photograph below with the hope that other dog-owners might be interested. To my extreme pleasure it was read by the Secretary of the Canine Defence League who asked permission to use the idea. In January, 1940, he sent me the following letter and a collar and lead both of extruded strip and compounded with luminous pigment:

> *"I should like to express my appreciation of your kind reference to our adoption of your idea of a luminous dog collar, and to say that these are proving increasingly popular. Although the collar so proudly worn by your Scottie has an historic interest, I venture to ask your kind acceptance of the accompanying collar and lead which your canine friend may like to use for everyday wear, so that the 'father of all luminous collars' may be reserved for state occasions. With best wishes for the continued success of your splendid trade journal, and with renewed thanks for your help. Charles Johns (Secretary), National Canine Defence League."*

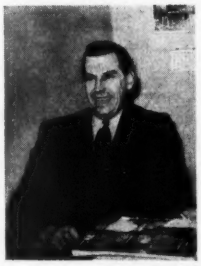
DOGSBODDY.

EXTRUSION OF PLASTICS

SPECIAL NUMBER

THIS issue of Plastics *is almost entirely devoted to the extrusion of plastics, a branch of our industry that had its beginnings about* 1870 *to* 1880 *and today has grown to interesting proportions with still greater possibilities in the future in the technical and economic fields. The subject matter has been presented, we hope, as a consecutive but far from complete story : the history of extrusion; the trends that have and will be taken; a technical consideration of the available machinery; the plastic raw materials that can be formed in them and finally some of the applications that have been produced during many years past. In all, we hope that it will present to the outside world of industry a readable picture of what this section of our industry can do. We also hope that it will prove of value to those who practise extrusion and to those who wish to do so.*

We have much pleasure in publishing below a message from Mr. Donal Sullivan who from within the industry itself has done so much in recent years to create some of its economic fortunes and to point the way to still greater ones.



HEARTIEST congratulations should be extended to Temple Press Ltd. for publishing this number on plastics extrusions. The devotion of a special issue of *Plastics* to the extrusion section of the industry is indicative of the growth in importance of this branch. Prior to 1935 there were probably no more than five extruding companies operating in this country whilst today there are more than 90.

This expansion has been accompanied by heartening progress in the technical field which owes some of its achievement to a marked degree of co-operation in recent years between the raw material manufacturers, the plant makers and the extruders. Earlier co-operation might have been forthcoming if others had realized that the tremendous expansion of which the early extruders spoke was not just another dream ; few then would recognize, let alone cater for, their specialized requirements.

The gravest danger to the plastics extrusion industry today is the fear that in trying to expand too hastily, some enthusiastic salesman may overlook the need for the maintenance of high quality and absolute certainty of the suitability of the extrusion for each and every application. A wide range of materials is now available and every care must be taken to assure that only the best for each specific application is supplied. There will be many occasions when extruders will be asked to supply their products for use in circumstances which might be regarded as dubious. Adequate tests must be applied to clear all doubts and misapplications avoided at all costs. All too quickly are people inclined to generalize and therefore condemn " plastics extrusions " as being unsuitable for their use, just because someone who had not at heart the interest of the industry, his company or the customer and had supplied the wrong material in the first instance.

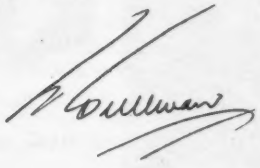
There has been a slight tendency in recent years for some extruders for alleged economic reasons to degrade a material in order to enter a field in which an extruded plastics product had already been proved suitable. This type of marketing is highly dangerous and whilst the individual supplier will pay the penalty, in the end the industry as a whole will also suffer.

The interests of all concerned can best be protected from some of these dangers by the publication, as soon as is practicable, of standard specifications. Considerable attention is being paid to this need by the British Plastics Federation where the essential co-operation between raw material suppliers and extruders is assured.

Extrusion is in fact a highly specialized art and the extruder can only prosper by selling his *services* to his customer. To do this he must make it his bounden duty to know all that is expected of the article he is asked to produce. Co-operation with his customer and material supplier at the earliest stage is therefore highly desirable. This will enable the proposed extrusion to be of the best possible design instead of it having to be made to fit into the recess which happens to have been left for it when all the other components have been manufactured.

The extruder cannot be expected to know all the problems associated with all his customers' products, but he must do his utmost to find out all he can and give the best possible advice. There can be few industries that are not now using extruded plastics in some form or another and the range of applications increases daily.

The future of the extruders is assured if they themselves will insist upon maintaining a reputation for protecting their customers' interests at all times, by never accepting an order unless satisfied that the extrusion called for is absolutely suitable for the job it will have to do. If business is conducted on these lines and all branches of the industry co-operate as they should, then in the near future more raw material will be consumed annually by extruders than in any other branch of the plastics industry.



The History of Extrusion

THE story of extrusion, even in its simplest form, does not appear to go back earlier than the work of Joseph Bramah who, in 1797, invented his hand-operated plunger and die for producing lead piping continuously. Today extrusion of a wide variety of profiles on a continuous or semi-continuous basis is carried out on most metals, on graphite for lead pencils, on carbon for electrodes, on concrete and ceramics, almost all the presses being of the hydraulic ram type.

It was left to the rubber and the plastics industry to seek the aid of one of the oldest inventions in history for the purpose, the Archimedean screw, which not only served to move the material to the die head but also as a very essential device for mixing giant organic molecules to produce extruded forms of good marketable quality. On the other hand the hydraulic ram is occasionally employed for specific jobs.

Both cellulose nitrate and rubber were extruded between 1870 and 1880. It was not until the first world war that casein was extruded and became of industrial importance. Both cellulose nitrate and casein were extruded as they still are, in rod and tube form for further manipulation and machining for a wide field of application, while much sheet casein is also made into sheet from extrusions cut into ribs which are then compressed. In this country the British Xylonite Co., Ltd., was the sole manufacturer of cellulose nitrate plastic and later both B.X. and Erinoid Ltd., were the largest manufacturers of casein.

Up to 1925 in this country at least (we exclude the phenolic resins which had not then been extruded and the bitumens) both these materials were the only plastic materials available, and although production was then considered considerable and competition in all fields very strong because of equally large-scale manufacture in Europe and Japan, the limitations in the characteristics of both prevented expansion into fields that today seem the prerogative of the newer synthetic plastics. It is easy to minimize the present value of celluloid and casein but they were for many years of outstanding importance; in their own fields in ease of manipulation, in toughness in the case of nitrate, in their exceptional colour values and their low cost both had opened up new fields in many of which they still retain a hold. Both productions moreover, from 1870 in the case of cellulose nitrate and about 1918 in the case of casein introduced techniques and "know-how" of types that have clearly helped the advent of the newer plastics.

Nevertheless the physical and chemical properties of the older types limited expansion such as has been achieved today by the modern plastics industry for obviously neither celluloid nor casein could have satisfied the more exigent specifications of the electrical, motorcar, aircraft and many other light and heavy industries. The plastics industry today has now in Gt. Britain a capacity of the order of some 250,000 tons whereas in 1918 it was little more than 7,000 tons.

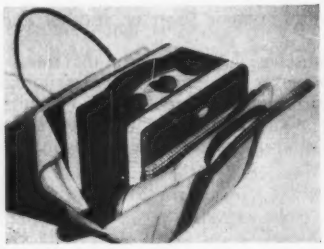
The plastics scene changed with the production of phenolic resins, cellulose acetate, and polyvinyl chloride between 1914 and 1930 but it was not until about 1931 that the new materials were being examined from the extrusion point of view; almost all this early work had been carried out in Germany.

So far as Gt. Britain is concerned it is clear that Mr. B. H. Hornung, who had already had a working experience in Germany, must be considered the pioneer in the extrusion of p.v.c. In 1933 he had settled in this country having brought with him several Heidrich extrusion machines (first made in 1931) and it is important to note that these were neither rubber extrusion machines nor even such machines suitably modified. They were in fact specifically designed for the extrusion of the new plastic materials. In that same year he created Suflex Ltd., producing plasticized p.v.c. sheathing and the first covering of wire for the electrical industry. Production in these works is still predominantly for the electrical industry.

About the year 1936 a company named Hydroplastics Ltd., was formed with Mr. Julius Veit as prime mover to carry out similar work. He had gained much experience in plastics in Germany and by working with Suflex Ltd. Hydroplastics Ltd., ceased operation a few years later and Mr. Veit formed a new company, Duratube and Wire Co., Ltd., which prospers today making a wide range of extrusions. About the same time Tenaplas Ltd., was formed, the character of the production of this company differing somewhat from the other two —the type of advances made can be judged by the fact that large-type extrusions (e.g., 12-in. polythene tubing), having been commonplace for some years.

It is interesting to note that in the year 1932 the rubber industry itself apparently took little or no part in the development of p.v.c. It had begun extruding rubber as long ago as 1880 and a "natural" economic resistance to the new synthetic material stultified further interest. Today and as a result of this resistance we may understand more clearly the divergence of the two branches. Rubber extrusion requires its own type of machine with a shorter and colder screw since rubber is a vulcanizable material and furthermore the rubber extruders must work adjacent to the calenders and mixers. Production and character of p.v.c. has enabled the raw material industry to deliver a completely mixed material in cold chip or powder form ready for extrusion, so that the plastics extrusion factory contains, so far as the plant is concerned, merely the extruding machine, its prime mover and take-off devices, and thus has obvious economic advantages.

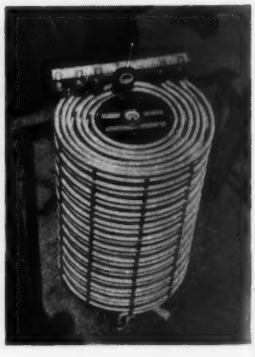
During the same period described above, about 1925-1936, small-scale extrusion of cellulose acetate and of polystyrene began (the latter extrusions being of interest to the electrical industry), while the "pure" p.v.c. without the addition of plasticizer was being extruded into rigid hard tubes in Germany where the chemical companies were becoming increasingly



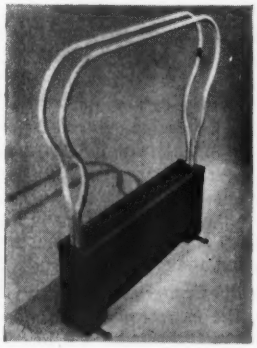
Left: Domestic waste-water pipes.

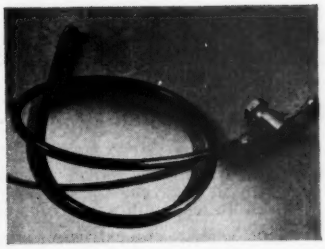
Above: Cabinet and bag handles.

Above: Brine pipes for refrigeration.



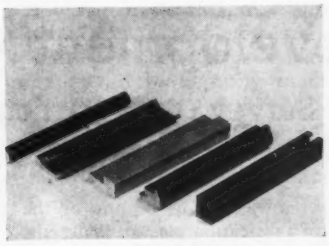
Right: Acid-cooling tower.





Left: Towel heater rails.

Above: Cycle brake cover.



Above: "Phenolic" beading.

Right: "Vinyl" monofilament.

conscious of the properties of this highly acid-resisting material. Obviously the use of "indigenous" organic materials of construction was greatly fostered by the German Government as a concomitant of the famous "Four Year Plans" of the Hitler regime.

In Gt. Britain extrusion of rigid p.v.c. in tubular form has only been introduced during the last few years but the need has not been so urgent because of the spectacular discovery and production of polythene before the late war and its extrusion in 1939. This highly acid-resistant material has been extruded here, as we have already indicated, in tubes 8 in. and 12 in. in diameter and of ½ in. wall thickness, for some years past.

Since the beginning of the war the even newer plastics, cellulose acetate butyrate, nylon, the silicones and polytetrafluorethylene (by a special process) are all extruded, so that today, the plastics industry is able to present to the world, a series of extruded forms made from about 12 different basic raw materials. Each possesses its own specific properties of hardness or softness and flexibility, of transparency or opacity, of medium or very high electrical resistance, some of low resistance to heat, others of high resistance to heat, most of exceptional value in resistance to acids and alkalis and many oils, all of infinite colour capacity, of considerable and sometimes exceptional strength, so that industry is now possessed of a vast range of new choices for its material of constructions undreamed of at the beginning of this century.

So far we have not touched on the extrusion of phenolic resins, extrusions which were first produced in the 1930s with great hopes, but to date, appear to be very limited in scope. First introduced into this country about 1932 by Rockhard Resins, Ltd. (now absorbed into British Resin Products, Ltd.*), the process was and still is successfully employed by Gestetner Ltd., using B.R.P. special phenolic resins, for the continuous production, on a hydraulic ram machine, of rollers for the famous Gestetner duplicating machines. An adequate description of this process was given in our June, 1937, issue and again in August, 1953: its perfection for this single purpose at the factory is manifest. British Resin Products, Ltd., also carry out a large number of extrusions of different profiles—printing ink rollers, towel-rollers, table-top edging and so on, but it appears that no other country has found adequate use for the process. The plastics extrusion industry may from the broad economic point of view, be considered the province of the thermoplastic resins.

To return to thermoplastic extrusion and the applications thereof. It seems clear that the first object in view was the covering of wire with p.v.c. for the electrical industry. The success originally achieved is shown from the fact that wire-covering and cable construction are the biggest users of p.v.c., polythene, nylon and polytetrafluorethylene. From this has also sprung the extrusion of p.v.c. on very thin wire for horticulture and general purposes and on thick wire for special types of construction where resistance to weather or attractive appearance or resistance to abrasion is an advantage. Strip p.v.c. came early on the market in the form of belts for men's and women's wear, but weakness at the holes in the early examples exposed a fault in a utility which the public were ensured would last "for ever." Post-war developments such as these, together with p.v.c. braces, wrist-watch straps and so on, have diminished in importance, but there is obviously room for a resuscitation of them, on a carefully considered basis.

It is interesting for us to remember that about 1942 we were presented with a bath-mat woven from 1-in. flat strip. Apparently the cost was too high then to put on the market but its value may be gathered that it is still in quite perfect condition after 11 years and that a similar type has recently been put on the market (see p. 432).

Since those days, p.v.c. has progressed as extrusions in what appears to be an ever-widening field, from hose pipes to automobile wing piping, stair treads to tool handles, from tap washers to cycle handlebars, from petrol hosing to draught excluders, from packaging tubes to ball-pen ink holders. Our photographs on another page in this issue give an adequate view of what has been accomplished and no doubt is merely a foretaste of the future.

So, too, with polythene, which has followed similar paths and which in many respects has achieved even greater importance to the country if we regard closely the problem of water supplies and agricultural irrigation and a variety of other facets of our industrial and normal life, such as chemical manufacture, refrigeration and even bottle manufacture. And so, too, with cellulose acetate and butyrate, and even with nylon, the value of which we are rapidly learning but cannot widely apply because of limited supplies. Indeed, the future of extrusion is assured, just as the future of plastics is brighter than most other industries.

But it is not merely a matter of new "armchair" ideas which have flowed for these many years, and will continued to flow for ever. The new applications will only fructify when traditional materials, and what is just as important, when traditional designs, are examined with new and critical eyes with a sound knowledge of the chemical and physical properties of plastics and by long acquaintance with them. It is this lack of knowledge that has been at the basis of all our failures in the past and we must see to it that all in the plastics industry are well grounded in it. But we are equally certain that the future of extruded plastics, indeed like any other branch, also lies in the hands of the workers in it—the raw-material makers, the machine makers and the extruders. Hand-in-hand with present production, there must be an incessant research to understand more about our very "intractable" raw materials, and this research must be translated to the machine maker on the one hand and to the extruder on the other, so that, by improved machine design and by proper working and control of the machines, the best results can be obtained.

* A member of the Distillers Company's group of subsidiaries.

The Development of Plastics Extrusion

A Survey, with Particular Reference to P.V.C.

By H. D. BRETT*

THE extrusion process is acknowledged to be one of the most important methods of fabricating plastics materials. Enormous quantities of plastics materials are used for covering cables and also for moulding tubes, rods, strips and profiles, as a continuous process.

The technique consists of forcing a plastic mass through an orifice of the appropriate shape. This is achieved by softening and consolidating the plastic raw material by compression in a heated cylinder, forming a viscous mass which is forced towards the head containing the die orifice. The pressure applied to the plastic mass in the cylinder is developed either by a ram or by a screw conveyor.

Thus, there are two main types of plastics extrusion machines and it is interesting to note that they were originally devised for the extrusion of gutta-percha:—[1]

(1) **The Extrusion Press, or Hydraulic Extrusion Machine.** Hand-operated extrusion presses were first used commercially in England about a century ago. Within a few years, the machines were mechanized and the process was firmly established.

(2) **The Screw Extrusion Machine.** The screw extrusion machine was first introduced by Francis Shaw in 1879 and it could be described as the ancestor of the modern plastics extruder.

Extrusion of Plastics in the Second World War

It is recognized that the war promoted the rapid development of the plastics industry. The modern conception of the extrusion process was initiated during those historic years.

At the outbreak of the war, there were already many established methods of extrusion, but the development of synthetic materials necessitated new techniques.

Most of the extrusion machines in use at that time were designed for the extrusion of rubber and were aptly termed "rubber forcing machines." A number of plastics extrusion machines had been in operation for many years, but the majority had been developed for the cellulosic and protein plastics. There were also machines designed for the extrusion of the phenolics. The development of efficient extruders for the new thermoplastics, such as p.v.c., polythene and polystyrene, was in its infancy.

Reviewing the position at the commencement of the war, the extrusion of plastics incorporated the following materials and processes:—

(a) **Cellulosics.** (Cellulose nitrate and cellulose acetate.) Large quantities of these thermoplastics were extruded by the so-called wet extrusion process, using the hydraulic type of machine.

This method is based upon the extrusion of a plastic mass containing volatile solvents, which are subsequently removed by hanging the extrusions in stoves at controlled temperatures. The plastic is first prepared by mixing the ingredients in a Werner Pfleiderer type mixer. After filtration, the material is mixed on heated roll mills, removing the excess of volatile solvents. The plastic mass is then calendered and rolled into cylindrical form, in order to fit the cylinder of the extruder. This type of machine is usually steam-heated, effectively softening the plastic, which can then be forced through the die by the operation of the hydraulic ram.

Screw extrusion machines were also in use for the extrusion of cellulosics, employing chips cut from the calendered sheet.

(b) **Casein.** The extrusion procedure for this protein plastic was already firmly established, utilizing a screw-type extruder.

(c) **Phenolics and Thermo-setting Plastics.** Although it was then a comparatively new process, the extrusion of thermo-setting materials by the use of a modified hydraulic extrusion machine was already in operation on a commercial scale[2].

(d) **The New Thermoplastics.** Although many new thermoplastics were developed in the years immediately preceding the war, p.v.c. and polythene were especially important, because of their excellent electrical characteristics. Thus, with the outbreak of war and the increasing shortage of rubber, the extrusion of the new flexible materials was developed mainly for insulation purposes.

The dry extrusion process, employing the screw-type rubber forcing machine, had already been investigated and used on a commercial scale for the manufacture of p.v.c. insulated cables, but the extrusion of polythene was then virtually experimental.

Many difficulties were encountered in adapting the rubber extruders for use with p.v.c. and polythene, as the new materials proved to be more heat-sensitive than rubber and higher processing temperatures were required. These difficulties were overcome by close co-operation between all branches of the extrusion industry by team-work between chemists and engineers, for the plastics raw materials had to be modified, as well as the machines.

The evolution of this technique can be illustrated by surveying the progress that has been made in the extrusion of p.v.c.

P.V.C. and the Extrusion Process

In the early years of the war, the technologists engaged in the urgent task of developing p.v.c. for insulation purposes were already visualizing the possibilities of the material for post-war applications. The versatility of the new polymer was soon apparent—flexible and rigid products could be made by compounding the p.v.c. with suitable plasticizers.

Many applications originated through trivial improvisations in the daily routine. Trial extrusions vanished from the laboratory benches and reappeared as shoe-laces, belts and other items. Such incidents were often of great value; the shoe-laces became very stiff in cold weather; the belts stained ladies' frocks; the flexible tubing used for piping water lost much of its flexibility in service; improvised "string" for parcels appeared to vary in strength. The observation of these faults promoted further development, both in the formulation of p.v.c. compounds and in the extrusion technique. The chemists reformulated the plastic compounds; the engineers redesigned the extrusion machines and equipment. This joint effort was rewarded by the evaluation of an extensive range of plastics materials which could be successfully extruded at a very high rate of production.

Some of the factors which have influenced the development of p.v.c. extrusions are described below:—

(1) **Demand.** This is, of course, essential to any industry, but it is important to note that the original demand for p.v.c. extrusions was caused by the shortage of other materials, such as rubber and metal. However, during recent years, the market for extruded plastics has expanded through the unique properties of the p.v.c. materials, which have become firmly established on their own merits.

*Vinatex Ltd.

The demand for p.v.c. extrusions has also been increased by the economical prices of the majority of extruded sections. Initially, p.v.c. extrusions were considered to be too expensive for general use, but this difficulty has been overcome by the enormous increase in the output of plastics materials. The extent of this achievement can be appreciated by comparison with other industries, for during the past ten years there has been a substantial increase in the prices of most of the competitive materials. Thus, the position has been reversed and it is often more economical to use plastics.

(2) **Raw Materials.** The essential raw materials for p.v.c. compounds are well known. Many new polymers, plasticizers, stabilizers and pigments have been introduced during recent years and have been invaluable in the development of the extrusion process. The importance of the raw materials cannot be over-emphasized.

The pioneers will remember the unstable compounds; the days when the extrusion heads were blown off the machines by the decomposition of the p.v.c., emitting clouds of hydrochloric acid gas. Yes, it was often necessary to strip and clean the machines every three hours. Now, the plant can operate continuously for days, with very little attention—largely due to the excellent heat stability imparted by the use of modern polymers and stabilizers.

Likewise, the compounds have been greatly improved by the progressive introduction of new plasticizers, which have played an important part in the development of p.v.c.

The p.v.c. compounds manufactured during the early days of the war were usually plasticized with tricresyl phosphate and dibutyl phthalate as they were virtually the only suitable plasticizers which could be obtained in commercial quantities. Thus, many of the insulation compounds did not have very good electrical properties and the extrusions showed poor flexibility at low temperatures. When di-octyl phthalate became available in bulk quantities, p.v.c. insulations entered a new era, with improved electrical characteristics and better cold flexibility.

Another important development is the commercial production of polyester plasticizers, which are being used in non-migratory sheathing. There are many other industrial applications which have not been fully explored. One example is the use of polyesters in the manufacture of flexible tubing for piping oils and petroleum. Originally, p.v.c. fuel pipes were plasticized with dibutyl phthalate. Although the plasticizer was extracted by the petroleum, the pipes were fairly satisfactory when in contact with the fuel, but became brittle when dry.

Plastics are renowned for their bright and attractive colours, but the earlier p.v.c. extrusions were rather drab. Apart from the amber shade of the base material, many of the pigments in use at that time were quite unsuitable for p.v.c. The introduction of a range of non-migratory pigments, stable to light and heat, has been a great asset to the industry.

(3) **Compounding.** It has been said that one can extrude a good compound on a bad machine, but one cannot extrude a bad compound on a good machine.

During the early years of the war a number of compounds had poor heat stability and were not fully gelatinized. The resultant extrusions were of poor quality, both in appearance and physical characteristics. These defects were overcome by the utilization of better raw materials and by compounding at higher temperatures.

At first, p.v.c. compounds were supplied in strip form, following rubber practice, but a " surge " developed when the material was fed to the extrusion machine, causing variable pressures on the die orifice and making it difficult to maintain uniformity in the extruded section. The material was then tested in shredded and granulated forms, with encouraging results. It was eventually proved that the form of the material influenced output and quality. Hence, modern compounds are usually supplied in granulated or " diced " forms.

A recent development is " extruder-compounding," where a powder premix is fed into a modern screw extrusion machine. It is thus possible to compound and extrude in one continuous operation. However, many manufacturers of extrusions have compromised by extruding a blend of natural compound and " colour concentrates," effectually reducing their range of stock compounds.

(4) **Extrusion Machines.** Extrusion machines are described in a survey published in this issue, but it is interesting to note how the modern machines have been evolved from those designed for processing rubber.

Initially, the higher temperatures needed for the extrusion of p.v.c. were usually provided by the addition of an electrically heated extension to the head of a rubber forcing machine.

Then the thermal instability of p.v.c. had to be considered, for it was difficult to heat the plastic uniformly without decomposition. The heads and dies were streamlined, in order to avoid the accumulation of p.v.c. and the subsequent overheating of the static material. It was also found that the decomposition of the p.v.c. was less apparent in dies made from polished stainless steel, resulting in the adoption of stainless steel liners for the head and barrel of the machine.

The streamlining of the machines created another problem, for the plastic material passed quickly through the barrel without the thorough mastication necessary to convert the compound into a homogeneous mass. An early remedy was the incorporation of breaker plates and screens in the die head. Later, better results were obtained by the introduction of longer screws of improved design, then variable speed drives were added, enabling control of output.

Within the past few years many new machines have been designed and marketed especially for the extrusion of p.v.c. and other thermoplastics. The most striking feature is the enormous potential capacity of these modern extruders. The pioneers struggled with their adapted rubber forcers and produced sleevings at the rate of a few pounds per hour. Now it is possible to attain an output of 200 lb. per hour, or more, making tubing several inches in diameter.

(5) **Extrusion Technique.** The methods adopted for the manufacture of p.v.c. extrusions are legion and cannot be described in a brief survey. Great ingenuity has been shown in the development of these processes, some of which are mentioned below.

One of the oldest extrusion processes, the covering of wire by the use of a T-head extruder, has been adapted for many applications. For example, metal spring rods have been coated with p.v.c. for expanding curtain rails and natural fibres have been coated for washable clothes lines.

The manufacture of extruded sheeting by the extrusion of a tube, slit at one point, is also an old process, but it is now possible to manufacture sheeting a few feet in width.

A comparatively recent development is the use of twin machines for the production of two-colour extrusions.

Perhaps the greatest advancements have been made in the technique for extruding rigid p.v.c., which can now be processed into a range of extrusions, including large and small sections to very close tolerances.

The Future of the Extrusion Process

The success achieved by those engaged in the development of the plastics extrusion process stimulated the interest of industrialists and resulted in the development of many new applications not envisaged by the pioneers of the technique.

Manufacturers of thermoplastics have noted the continuous expansion of the extrusion business through the varied nature of the inquiries received for extrusion compounds. An analysis of these inquiries, together with a survey of the wide variety of successful applications, show the advancements which have been made during recent years and also provide

(*Continued on page 423*)

Problems and Trends in Modern Screw Extruders for Thermoplastic Materials

By E. GASPAR, A.M.I.Mech.E.* and G. ROWE†

THE ever widening range of thermoplastic materials and the application of extrusion into new fields demand a fresh approach from thermoplastic extruder manufacturers.

The basic requirements of an extruder are:—

1. Feeding of material in the granulated or sometimes powder form.
2. Heating of the material to melt temperature.
3. Working and mixing of the material.
4. Building up a certain pressure at the extrusion die required to extrude the material.

Extruders are used essentially for:—

(a) Production of continuous length sections.
(b) Compounding, in which case the extruded sections are cut to produce granules.
(c) There are applications where continuous lengths of extruded section are produced from a premix where the material is not fed in granulated and coloured form but in the primary polymer form with added plasticizers, lubricants, fillers, stabilizers and colouring pigments. In this case the extruder has to fulfil the dual purpose of compounding and extruding.

The almost universally applied principle of carrying out the above duties is the application of a rotating Archimedean screw in a heated barrel. By careful design of the screw it is possible to use it for feeding the material from a hopper and then working and compressing the material and finally metering into the extrusion die. With certain materials the metering section is replaced with a smear head for pressure increase and greater mixing. (Fig. 1.)

Plastic material receives the heat required by friction caused by the movement of the material within the lands of the screw, and by conduction heating through the heated barrel in which the screw is rotated. The movement of the plastic material in the lands of the screw is dependent upon a number of factors which will be dealt with later. It has been found, however, that with various materials having a wide range of melt viscosity, the movement of the material in the lands varies considerably.

These considerations indicate that an extruder should be approached as a machine having a screw designed for a certain material and a certain purpose, together with a mechanism which is the shell of this screw and which applies the motive power to the screw. Theoretically, there should be a different screw design for every material and application. On the other hand, with careful consideration of a number of essential requirements, it is possible to design this mechanism to fulfil the requirements of most commercial thermoplastic materials and use this either for extrusion or for compounding.

The essential requirements of an extruder from a mechanical point of view could be summed up as follows:—

A. Mechanical constructional details

1. *Adequate and flexible power.* Due to the wide variations of sections, the maximum speed will vary at which the material is extruded with satisfactory finish. The drive of the extruder should be infinitely variable. For reasons explained below it is preferable to apply the heat to the plastic material up to a certain limit by mechanical work. The drive of the extruder should be sufficiently powerful, therefore, to supply this heat in addition to the normal mechanical requirements of a rotating screw.

* Chief Designer, † Extrusion Development Engineer (Projectile and Engineering Co., Ltd.)

2. *Adequate thrust races.* Efficient extrusion requires a certain minimum pressure which is built up in the material at the extruder head. The extruder screw should have an adequate thrust race to absorb this axial thrust and give long life with minimum attention.

3. *Flexibility of die attachment.* To allow for a wide variety and shape of dies to be attached to the machine, such as cable covering, section extrusion and film extrusion, the extruder should provide for the possibility of several methods of die attachment. There are three methods most commonly used, which are bolting, ring clamping and hinged die plate type. With all these methods of attachment great care has to be taken that the mass of metal is reduced to the minimum and the section kept constant to ensure correct temperature distribution and control in the die head.

4. *Provision for varying barrel lengths.* In certain instances, the length/diameter ratio of the screw is varied to get the best conditions. The mechanical construction of the barrel which houses the screw should, therefore, be such that the length could be varied. Liners for the barrel have to be corrosion resistant and at the same time ensure long life and eliminate scoring.

5. *Control of barrel and screw temperature.* Whilst it is desirable to apply heat to the plastic material to a large extent by friction, this has to be supplemented by external heat through the barrel. It has already been mentioned that a large percentage of the heat applied to the plastic material is generated by friction due to the movement of the material in the land of the screw. This movement varies along the length of the screw and the heat generated varies with it. Further variation of this frictional heat is due to the variation of the screw speed. It will be seen from this that heat has to be added or, alternatively, withdrawn from the plastic material to ensure close temperature control dependent upon the type of plastic material, etc. The barrel should be provided therefore with adequate heating and cooling facilities. These heating and cooling facilities should also be broken up into zones to ensure close temperature control along the length of the barrel. It is important to reduce temperature fluctuations, i.e., "hunting," to the minimum and, therefore, accurate temperature controllers, preferably of the potentiometer type, are required, coupled with quick-acting automatic valves which introduce or cut off water cooling in the various zones to maintain constant temperatures. Very often the speed of the screw and thus the output of the extruder is limited by the frictional heat, especially at the rear end of the screw where internal friction is reduced, external heat has to be applied to the material. It would, therefore, be possible to increase the speed and the output of the extruder if the rear portion of the barrel is cooled sufficiently to overcome compensated excessive frictional heat, whilst the front part of the extruder would still require heating by external means. In addition to this, however, it is important to provide means for accurate control of the screw temperature. Due to the excessive frictional heat at the rear end of the screw it is advisable to maintain lower screw temperatures at the rear end than at the front end, i.e., it is advisable to have a gradually increasing screw temperature. In order to achieve this, water should be introduced on the outside of an internal annulus and withdrawn through a central tube

forming the inside diameter of this annulus. The coolant, which is introduced, would gradually warm as it moves forward to the front end of the screw and thus it would achieve the required temperature gradient. It is advisable with certain materials to maintain constant screw temperatures and, whilst in many cases control of the volume of water is sufficient, in some cases a water temperature controller should be introduced to maintain a close circuit between the screw and the temperature controller and to provide the maximum volume of water at a given temperature. This not only influences the quality of extrusion with certain materials, but also increases the output of all materials.

7. *Easy removal of the screw.* It has already been stated that it is advisable to have different types of screws for different applications. It is, therefore, important to provide means of easy removal of the screw from the machine for changing. Also, if the screw extraction is simple, material can be saved when changing colour by cleaning the screw without undue loss of production time.

8. *Movable control cabinet.* All instruments controlling speeds and temperatures should be housed in a separate control cabinet. For various applications, such as cable covering, sheet extrusion, etc., it is advisable to change the position of the control cabinet as this facilitates operational control.

9. *Accessibility.* All components of the machine should be easily accessible. The hopper should be easily removable for cleaning. Space under the barrel to facilitate take-off in case of sheet extrusion. The drive should be preferably built in units and easily accessible for lubrication. Means should also be provided for easy removal of plastic material from the rear portion of the screw, and for protecting the thrust races from ingress of plastic materials.

B. Screw design

Extruders are fitted either with a single screw or, alternatively, two or more intermeshing screws or gears. The multi-screw machine has been developed comparatively recently and is giving good service on a number of applications. It can be assumed that the multi-intermeshing screws or gears have a positive pumping effect with some materials, i.e. p.v.c. resins; this action should be advantageous. However, there appears at present little information available as to the flow of plastic material along the screw. On the other hand, the conditions prevailing in a single screw extruder have been theoretically and experimentally investigated, which gives us sufficient data to predict conditions and indicate future trends. This article therefore deals with single screw extruders only.

As indicated in Fig. 1, the screw is made up of three sections:—

(a) **Feed zone,** which ensures the feed of the granular material. The helical channel of the screw must be deep and wide enough to take the material at the required rate in its granular or premix form.

(b) **Compression zone,** which compensates for the larger bulk factor of the material in the granular state and thus feeds partially melted and compressed material to the metering zone. The compression within the screw can be applied by:—

(i) Diminishing the pitch of the screw: If the pitch is varied it has been found that the helical channel has to be deep in order to achieve a fair output. A deep helical channel, however, in the metering section would cause an appreciable drop of output at high pressures due to the comparatively large area of the helix face. The output characteristics as a function of pressure will be steep.

(ii) Decreasing the depth of screw at a constant pitch: In this case the metering section would be relatively shallow, thus the output would be less dependent upon back pressure set up in the die. The output characteristic will be relatively flat. It is, therefore, generally preferred to use varying depths with constant pitch as the method of compressing the material.

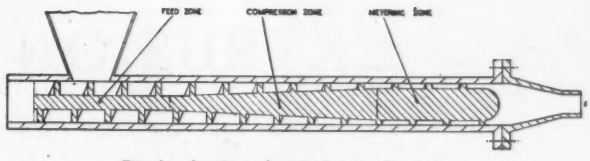


Fig. 1.—Section of typical extruder screw.

(c) **Metering zone.** This mixes and works the material before delivery to the die. It is appreciated that the forward movement of the plastic material in this metering zone is a resultant of four different flows. Messrs. Gore, Carley and McKelvey in U.S.A., and Messrs. Rigby, Owen and Atkinson in this country, have defined this flow as the resultant of

(i) drag flow, which is parallel with the helix of the screw;

(ii) back-pressure flow, which is the back flow of the material due to the pressure build-up in the die;

(iii) transverse flow, which is the flow within the land of the screw.

(iv) leakage flow, which is the back flow between the screw and the liner of the barrel.

It is beyond the scope of this article to explain and evaluate these various flows but it will be appreciated that the resultant flow will be dependent upon: 1. Viscosity curve of the material. 2. Characteristics of the screw, i.e., helix angle, depth of flight, width of land, number of starts, etc. 3. Pressure at the die.

In certain applications when the extruder is used predominantly as a compounder, i.e., when cellulose acetate or polystyrene premix is extruded for pelletizing, a "smear head" or torpedo is attached to a shortened metering section. This smear head increases back pressure flow and leakage flow and fulfils the additional function of smearing and rolling of thermoplastic material within this section. This ensures good mixing and dispersion and prevents pulsation.

If an extruder is used as a compounder the primary consideration is the mixing of the material and, therefore, the output efficiency of the screw has to be kept purposely low; in fact the screw would have to be designed to be sensitive to back flow and, in addition, have a relatively high transverse flow.

It will be realized that the behaviour of the screw will be dependent to a very large extent upon the viscosity characteristic, bulk factor, melting temperature and other characteristics of the material upon the maximum pressure required for a particular die section. Various compromises had to be made in the past to evolve a universal screw which would give a reasonable output with most of the thermoplastic materials within a wide range of extruded sections and also which could be used satisfactorily for compounding.

It is suggested that special screws designed for various materials and various applications would mean only a relatively low additional capital expenditure. The output from these screws on the other hand may be increased as much as 100% without detriment to the quality of the extrusion. Furthermore, it would enable the user to attempt the extrusion of sections which hitherto have been beyond the capacity of a standard all-purpose screw.

An extensive series of experiments is now being carried out* and the results will be published as soon as the experiments are more advanced, but, in the meantime as a general

(*Continued on page 439*)

* By Projectile and Engineering Co., Ltd.

EXTRUSION MACHINES

A great variety of machines and ancillary equipment is today available for the manufacture of tubes, sections, film and sheet as well as for covering wires and cables. In the following pages examples of machines made in all parts of the world are described. Where full information is available the description is divided under these headings: *Screw and Cylinder; Die Head; Drive; Heating; Output; Size; Weight;* and *Other Features.* Instruments, take-off equipment and ancillary machines such as cutters and granulators are also described.

ANDOUART, manufactured by Ets. Andouart, Ave Jean-Jaurès, Bezons (Seine-et-Oise), France. Represented by Warbrick (Engineering Specialists), Ltd., Warrington, Lancs.

THIS French company produces a range of simple screw extruders for the rubber and plastics industry as well as a straining machine with an output between 1,100 lb. and 2,200 lb. per hour according to the component used. The details of plastics extruders are:—

Screw and Cylinder: Case-hardened steel, ground, polished and chromium-plated; various profiles according to purpose, all centrally bored for water cooling. Diameters $1\frac{9}{16}$ in., $2\frac{3}{8}$ in., $3\frac{9}{16}$ in., $4\frac{3}{4}$ in., 6 in. Cylinders milled from steel billets, with water-cooled cast-steel hopper.

Die Head: Straight, side delivery or straining heads; certain heads are split and hinge mounted for easy cleaning.

Motor and Drive: $1\frac{9}{16}$ in. model: motor with v.s. drive having 1:6 ratio, mechanical transmission and reduction gear drive. Other models are fitted alternatively with three or four speeds or single speed driven from v.s. motor. Splash lubricated roller bearings. Drive mechanism enclosed in oil-tight case.

Heating: Removable resistance elements sunk in barrel. Control is for 3, 5 or 6 pyrometer zones, e.g. 3 or 4 for barrel, 1 for die head, 1 for die. Temperatures up to 250° C. can be obtained on special orders. Separate control panel.

Other Features: Vibratory feeding equipment for feeding chips is available. Take-off equipment for wire and cables comprises unit taking reels up to 24-in. diameter, or 42-in. diameter for the larger extruders.

BANDERA, made by Luigi Bandera, Via Carlo Poerio F, Busto Arsizio, Italy, sold by Covema, Via Fontana, 18, Milan, Italy.

THESE Italian manufacturers make a series of machines ranging from 30 mm. ($1\frac{1}{4}$ in.) to 100 mm. (4 in.). Single screw extruders.

Type T.30

Screw and Cylinder: Chrome nickel steel hardened and ground screw $1\frac{1}{2}$ in. diameter. Cast iron cylinder with sleeve.

Die Head: Hinge-type.

Drive: 1.8 h.p. motor with cone pulley drive giving four speeds: 28, 39, 55 and 77 r.p.m.

Heating: Two cylinder zones controlled by thermo-regulators with maximum temperature 250° C. Controls mounted on a separate frame. Total load 2kW.

T.45

This model has the same general characteristics as above with the addition of a cored screw for cooling, pulley in two sections for heating and cooling. 4 h.p. motor, giving eight speeds. Alternative v.s. drive giving speeds from 7 to 120 r.p.m. Larger models have the same general characteristics.

Bandera also make granulating machines which may be coupled with extruders for the manufacture of moulding powders.

BERSTORFF, manufactured by Hermann Berstorff, Maschinenbauanstalt Gm.b.H., Hanover. Agents: International Corporation, Ltd., 19 Ebury Street, London, S.W.1.

THE range of German-built Berstorff extrusion equipment includes single-screw extruders of 30 mm., 45 mm., 60 mm., 90 mm. and 120 mm. diameter. Special types include an 8-in. model for making unplasticized p.v.c. tubing to $6\frac{1}{4}$-in. diameter and a straining machine with an output of 2-$2\frac{1}{2}$ tons per hour.

Standard Plastics Extruder

Screw and Cylinders: 60 mm. diameter, steel screw, hard chrome plated, length 15D (profile and length can be varied to suit individual requirements.) Runs in internally hardened sleeve of nitriding steel and is arranged for water cooling; quickly interchangeable.

Die Head: Hinged; secured to the barrel by easily operated screw lock.

Heating: The barrel is in two separately-heated sections as are the head and the die. These four zones are separately and automatically controlled by an electric fine control regulator. The barrel also has five water-cooling zones, separately controllable by valves.

Drive: Electric motor and PIV variable-speed gear built into the machine; screw speed variable from 15-900 r.p.m. Clutch between the PIV gear and the machine makes it possible to vary speed setting while the machine is stationary, and also protects the machine against overloading.

Other Features: Models with the same basic features are built with 45, 60, 90 and 120 mm. diameter (1.8, 2.4, 3.5 and 4.7 in.).

DAVID BRIDGE AND CO., LTD. Castleton Works, Castleton, Rochdale, Lancs.

THE range of plastics screw extrusion machines made by Bridge is from 1-in. laboratory extruders to 8-in.-diameter straining machines for purifying compounds. These include a bench-type laboratory extruder with 1-in. screw, with single or variable-speed drive; two-zone cylinder heating and separate die heater with indicating pyrometers and Sunvic energy regulator controls; a $1\frac{1}{4}$-in. laboratory and process testing machine; a $2\frac{1}{2}$-in. extruder designed for handling casein. A Bridge-Farrel 6-in. process extruder of the Gordon-Plasticator type and a plastics straining machine with 8-in. screw and twin-roller feed.

Their screw extruder for handling thermoplastics like p.v.c., polythene, nylon, etc., are made on the same basis in a number of screw sizes. A specification of the $3\frac{1}{2}$-in. machine indicates the general details of the range.

In addition to the extruding machines Bridge also supply take-off equipment; a wire-coating set-up with $4\frac{1}{2}$-in. extruder is shown on page 415. For servicing extruders with oil heating, an electrically operated unit for heating, cooling and circulating oil is supplied.

$3\frac{1}{2}$-in. Bridelectric

Screw and Cylinder: $3\frac{1}{2}$-in.-diameter screw of special non-rusting steel; flights are hard welded, ground and highly polished; internally bored for cooling; rapid removal from cylinder. Cylinder has hardened removable liner mounted on combined drive and thrust unit. Water-cooled feed picket suitable for cold strip or hot strip feeding.

Die Head: Straight delivery steel head for tubes and sections including die, core-holder, strainer plate, die-holder adjustment; screw-mounted with hinged fitting. Die head heating zone controlled by Ether-Wheelco controller.

Motor and Drive: 30/$7\frac{1}{2}$ h.p., 1,500/380 r.p.m. V.S. motor; combined thrust and drive unit with helical gearing, all gear bearings and screw mounting are ball or roller bearings. Screw speed infinitely variable between 22-90 r.p.m.

Heating: Three electrically heated cylinder zones each controlled by Ether-Wheelco Capacitrol instruments, separately panel-mounted; range 100°-350° C. Air-cooling of cylinder in each zone by blowers operated by the instruments. Cylinder is lagged for efficiency and thermal uniformity with streamlined lagging case, easily removable. An air-gap between cylinder and drive-thrust unit prevents heat transfer to drive.

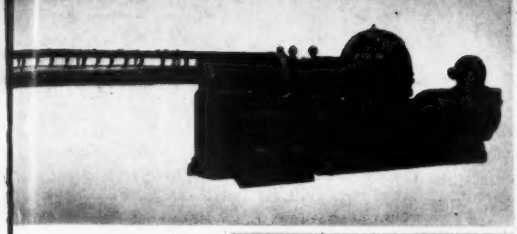
Other features: Vibratory feeder, screw speed indicator. Models of similar construction are made with different screw diameters.

Size: 10 ft. by 6 ft. floor space.

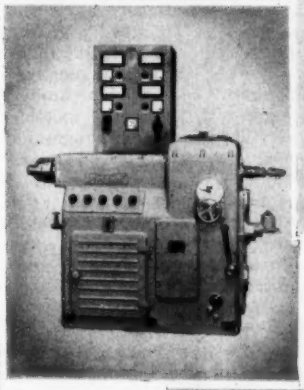
DAVIS-STANDARD, manufactured by Standard Machinery Co., Mystic, Conn., U.S.A. Representatives: Finney Presses, Ltd., Berkeley Street, Birmingham, 1.

THE American manufacturers of these machines claim to be the world's largest manufacturers of custom-built extrusion machines for rubber and plastics. A deputation which recently returned from the U.S.A., included a special mention of the

(*Continued on page* 412)



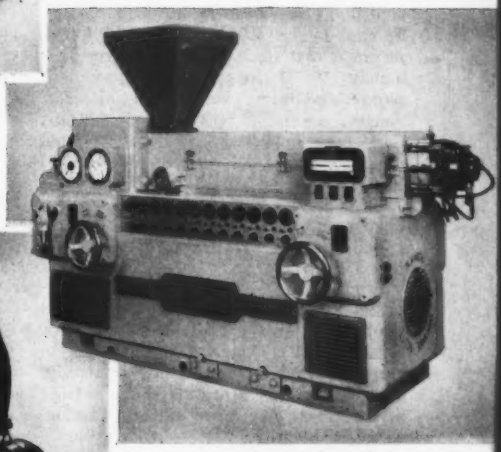
(Above) Iddon 6" extruder with special electrically-heated head for extruding polythene film.



(Right) Berstorff 60-mm. plastics extruder.

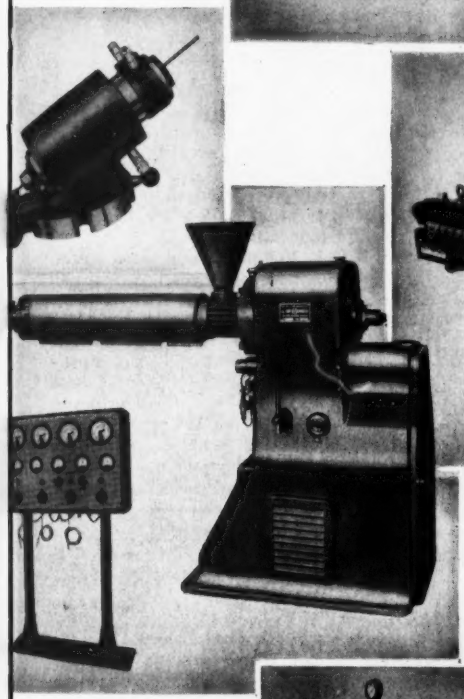
(Above) Mapré contra-rotating twin-screw extruder with vibratory feed.

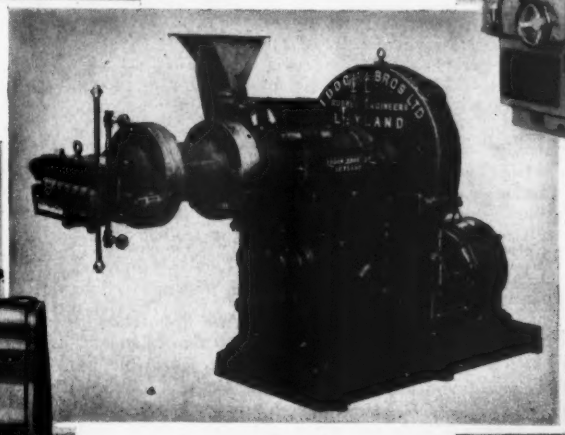
(Above) Bridge-Farrel 6" process extruder for plastics. (Gordon Plasticator type.)



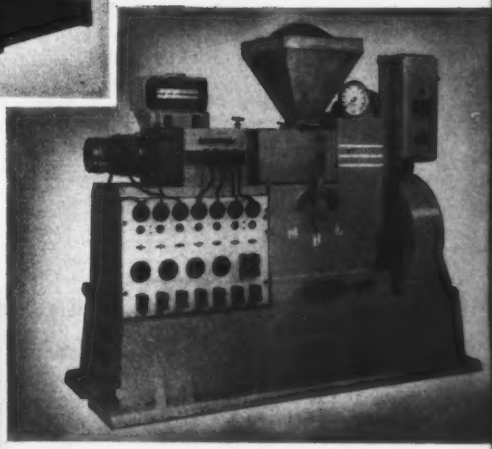
(Above) Mason 4½" single-screw extruder.

(Below) Mason 2½" extruder.

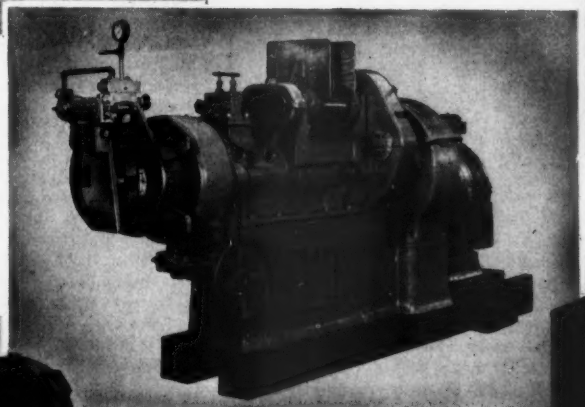




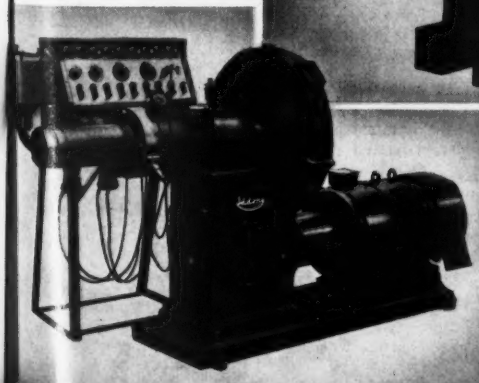
(Above) 4½" Iddon extruder with strip die-head.



(Above) Bandera T7 extruder, with control panel (not to scale), and (inset) 120° die-head for wire covering.

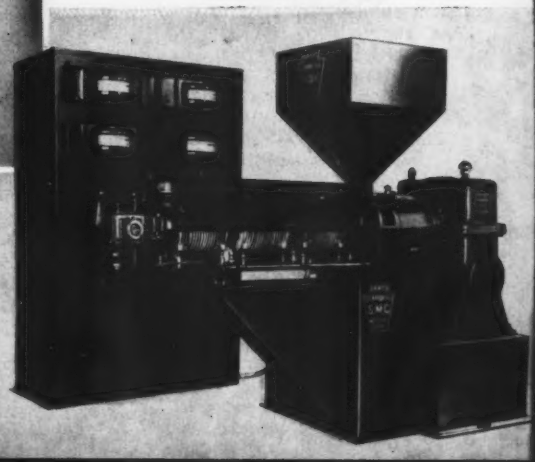


(Below) 3¼" Davis-Standard thermoplastic extruder fitted with cross-head.



(Above) Bridge plastics straining machine with 8" diameter screw and twin roller feed.

(Left) Iddon 2" plastics extruding machine with electrically-heated head for extrusion of polythene tubing.



EXTRUSION MACHINES

(*Continued from page 410*)

Davis-Standard machine in their report, stating that the ancillary equipment in particular is the best available in any country.

The following specification covers the range of extruders from 1¼-in. to 6-in. screw diameters.

Screw and Cylinder: Stock screw: constant pitch, decreasing depth in various ratios; made from high-tensile alloy steel, hard surfaced and equipped for temperature control. Diameters: 1¼ in., 2 in., 2½ in., 3¼ in., 3½ in., 4½ in., 6 in. Cylinder sectional cast steel construction, approximately 15 D long; corrosion-resistant removable liners; very small diameter flanges; special "Therma-Fin" heaters. Cast feed hopper with jacket cooling, integral-gap ring. Wire guard for cylinder.

Die Head: Straight or cross-head, hinged, opened by clamp ring and single nut; incorporating shear-pin to take predetermined pressure; floating type die-holders for rapid centering. Compact design ensures constant temperature gradient.

Drive: Adjustable-speed motors ranging from 3 h.p. (for 1¼ in.) to 100 h.p. (for 6-in. model). Type varies according to work required and is specified separately. Flat roller-type thrust bearings. High screw speeds give more uniform product in larger quantity.

Heating: Total load varies with screw size: 2½ kW. (1¼ in.), 8 kW. (2 in.), 12 kW. (2½ in., 3¼ in. and 3½ in.), 17 kW. (4¼ in.) and 23 kW. (6 in.). Proportioning type control instruments mounted on separate panels. "Therma-Fin" heating jackets, cast aluminium, with calrod-type tubular heating elements and cooling coil embedded.

Other features: Complete wire insulating assembly including pay-off reels, cooling water trough, wire-pulling capstan and two-reel continuous take-up—all synchronized with extruder speed.

Weights: 1,400 lb. (1¼ in.), 3,330 lb. (2 in.), 3,600 lb. (2½ in.), 6,450 lb. (3¼ in.), 6,600 lb. (3½ in.), 10,500 lb. (4½ in.), 15,000 lb. (6 in.).

IDDON, made by Iddon Brothers, Ltd., Leyland, Lancs.

MACHINERY for the rubber industry has always been a speciality of this company, and a large number of their rubber extruding machines are in use throughout the country. With the introduction of thermoplastics to the extrusion field, Iddon Brothers developed a large and varied range of plastics extruders. Brief descriptions of some of these machines intended for different purposes are given here:

3-in. electrically heated extruding machine, with variable speed motor drive through three-speed gearbox, with temperature control panel, vibratory feeder.

Bench-type plastic extruding machine with electrically heated cylinder and right-angle head. 1¼-in. diameter screw directly driven by geared motor.

2-in. electrically heated plastics extruding machine; constant-speed motor drive through three-speed gearbox; temperature control panel, vibratory feeder, straightway head, hinged to facilitate easy removal of the two-piece type screw for cleaning, or for replacement by screw of different contour.

2-in. plastics extruding machine driven by variable speed motor through three-speed gearbox, electrically heated cylinder and extension, fitted with electrically heated head for the extrusion of polythene tubing.

4½-in. electrically heated plastics extruding machine, driven by constant-speed motor through three-speed gearbox, fitted with temperature control panel, vibratory feeder and straightway head.

Oil-heated plastics extruding machine with heating unit, 3-in. diameter screws, fitted with right-angle head for cable covering. Driven by electric motor through V-belt drive and worm reducing gear.

6-in. plastics film extruding machine, driven by variable speed motor through three-speed gearbox, and fitted with special electrically heated head for the extrusion of polythene film.

MAPRE, made by Mapré S.A., Diekrich, Gd. Duchy of Luxembourg.

TWO sizes of twin-screw extruders are made, the characteristic feature being contra-rotating intermeshing screws of variable pitch providing positive forward thrust. The machines employ a feeding unit designed to take material fed in powder form, the screws being fed from a hopper and through a trough in which an Archimedean screw pre-mixes and feeds material at a constant rate.

E.2.600.80

Screw and Cylinder: Two intermeshing contra-rotating screws, 80 mm. diameter, 600 mm. long. Cylinder detachable by means of bayonet-type fixture.

Die Head: Straight heads for tubes, cross-heads for wires, granulating head with cutter for moulding chip manufacture.

Drive: 7.5 h.p. motor, infinitely variable speed drive giving screw speeds from 6-27 r.p.m. Shear-pin protects drive in case of overload or mechanical damage.

Heating: Three cylinder zones, band heaters 6 kW. capacity; thermostat-type controls mounted on panel of frame. Separate heater for feeding unit.

Output: 45 kg. (100 lb.) per hour maximum, dependent on materials and section.

Other Features: Mechanical screw feed mechanism.

Size: 150 x 82 x 200 cm.

Weight: 1,800 kg. (net).

E.2.700.92

Details for this machine are the same as for E.2.600.80 with the exception of the

Screw and Cylinder: 92 mm. diameter, 700 mm. long.

Drive: 11 h.p. motor giving screw speeds 6-27 r.p.m.

Heating: 8 kW. total capacity.

Output: 65 kg. (140 lb.) maximum.

Size: 1,700 mm. x 890 mm. x 2,000 mm.

Weight: 2,100 kg. (net).

MASON, made by N. Mason, A.M.I.P.E., 28b Guildford Street, Luton, Beds.

THIS manufacturer makes three standard sizes of extruder with screws of 1¼-in., 2½-in. and 4½-in. diameter. A complete range of take-off equipment is also supplied.

2½-in. All-electric Gate-head Extruder

Screw and Cylinder: Hardened steel water-cooled feed screw, 2½-in. diameter, running in cylinder with hardened steel renewable liners.

Die Head: Gate-type, arranged for 3-in. die face, fitted with die, torpedo, baffle plate and air intake tubes for tube extrusions. Cross-head supplied for wire covering.

Drive: 10 h.p. Brook totally enclosed surface-cooled motor; three-speed gearbox with gears running in oil, all bearings of ball and roller type. Alternative drives: 1, Variable-speed electric motor giving approx. 8-63 r.p.m. screw speed; 2, hydraulic variable Carter gear giving approx. 5-90 r.p.m. screw speed; 3, two-speed electric motor giving six speeds—24, 32, 37, 41, 49 and 63 r.p.m.

Heating: Seven band heaters total 2,100 watts, controlled by Sunvic thermostats and one Foster four-station temperature indicator.

Output: 40 to 70 lb. p.v.c. per hour.

4½ in. Extruder

Screw and Cylinder: Hardened steel water-cooled screw, 4½ in. diameter running in hardened steel liner. Gravity feed from steel hopper.

Die Head: Gate-type, arranged for 4½ in. die face with torpedo, baffle plate, air intake tubes for tube extrusions.

Drive: B.T.H., 30 h.p. variable speed motor, fully enclosed 2-speed gearbox with all steel gears running in oil. Screw speed variable from 8 to 76 r.p.m.

Heating: 12 band heaters, giving total load of 9,800 watts; Sunvic thermostats; Foster 6-station indicator.

Other Features: Cross-head for wire covering can be supplied. Complete wire coating equipment: variable speed haul-off unit, water cooling bath, etc. Take-off belt with Carter variable speed gear.

PASQUETTI, made by Ditta Carlo Pasquetti, Varese, Italy. Supplied by T. H. and J. Daniels, Ltd., Lightpill Ironworks, Stroud, Glos.

PASQUETTI make two types of extrusions machines. One type has two contra-rotating screws giving positive and continuous pumping, an effect particularly useful for mixing and compounding. The other type employs three pairs of bihelical gears running in a hot oil circulating chamber.

CP.2V.10

Screws and Cylinder: Two screws, 3-in. diameter, in three stages with 4, 3 and 2 starts to give increased compression.

Drive: 6 h.p. motor with 4 speeds (5, 8, 11 and 15 r.p.m.).

Heating: 1.9-kW. load with energy regulators and indicators mounted on machine frame.

Output: 44 to 88 lb. per hour according to material.

Size: 98 in. by 38 in. by 57 in.

Weight: 3,527 lb.

CP.1.100

Gears: Three pairs nickel-chrome steel bihelical gears 3⅞ in. diameter each, in oil-heated chamber.

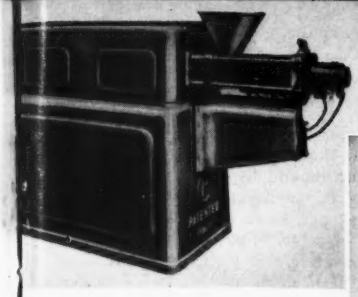
Die Head: Vertical.

Drive: 16 h.p. motor with hydraulic speed control, giving speeds from 1 to 20 r.p.m.

(*Continued on page 414*)

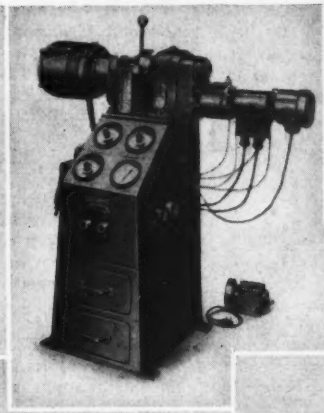
EXTRUSION MACHINES FOR PLASTICS

(Right) Reed 2-in. single-screw extruder.

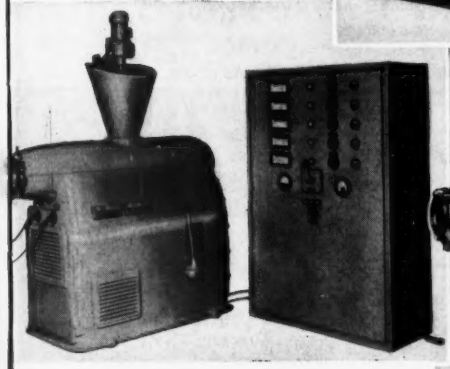


bove) Pasquetti model CP.2V.10
ntra-rotating twin-screw
extruder.

(Right) Trudex twin-screw
extruder.

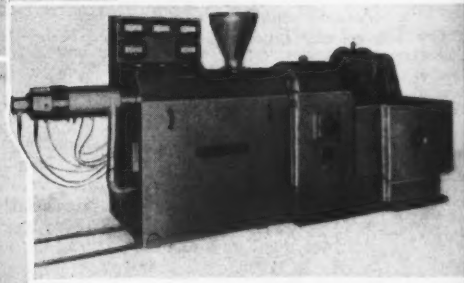


(Left) Shaw model P.1
experimental 1-in. screw
extruder.

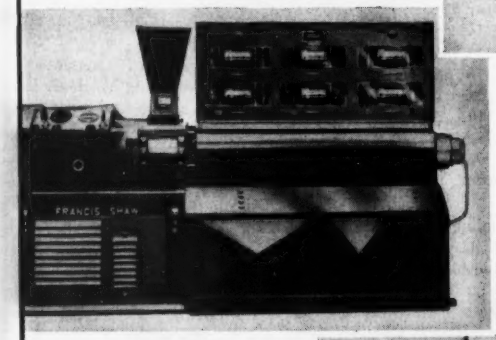


(Above) Reifenhauser S.90/RG
with control cabinet.

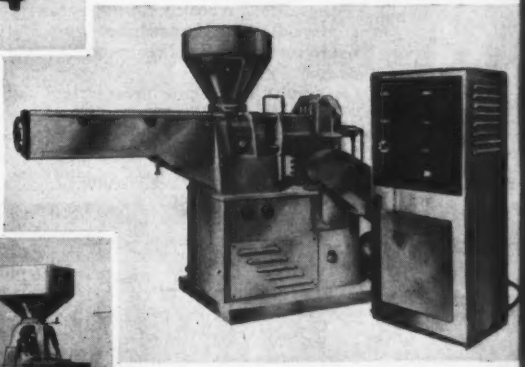
(Above) Windsor R.C.65
twin-screw extruder.



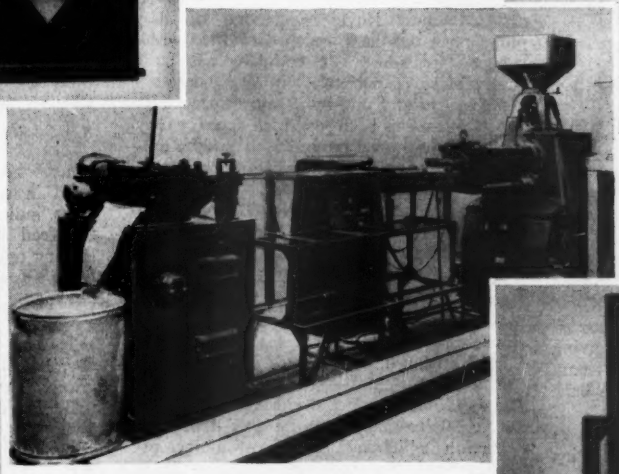
(Above) Troester, Series UP,
single-screw extruder.



(Above) Shaw 4½-in. extruder.



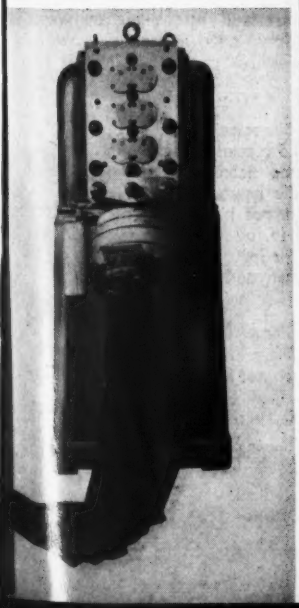
(Above) Peco 2½-in. extruder.

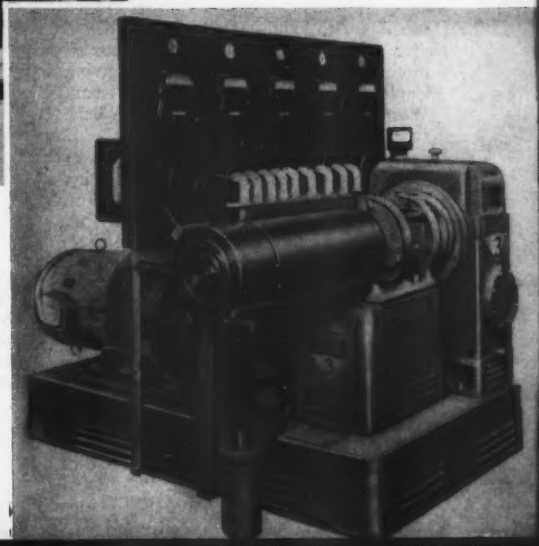


(Above) Windsor R.C.200 twin-screw extruder
and compounder with take-off system and cutter
for pelletizing polystyrene moulding material.
(Photo: O. and M. Kleemann, Ltd.)

(Right) Royle No. 3 single-screw extruder.

(Left) Pasquetti CP.1.100 bihelical gear
extruder and compounder.





EXTRUSION MACHINES

(*Continued from page 412*)

coupled to the reduction gear. Thermostat prevents motor starting before prefixed working temperature is reached.

Heating: Circulating oil electrically heated (15 kW.); circulating pump motor: 1.2 h.p.

Output: 220 to 330 lb. per hour nominal capacity.

Size: 97 in. by 40 in. by 73 in.

PECO, made by Projectile and Engineering Co., Ltd., Acre Street, Battersea, London, S.W.8.

THIS company introduced their first plastics extruder earlier this year. Considerable modifications have been made from the prototype shown at the British Plastics Exhibition. A special feature of the machine is variation in screw profile and also in screw length by addition of an extra barrel section.

Screw and Cylinder: For plasticized p.v.c.: a single-start fully flighted type, length 11D; longer screw for rigid p.v.c.; smear heads and 16D length for cellulose acetate and polystyrene. 16D fully flighted type for polythene and nylon.

Die Head: Direct bolting or yoke clamp.

Drive: 15 h.p. motor working through mechanical v.s. drive, worm reduction box and steel reinforced V-belts. Flat roller type thrust race, maximum thrust 21,000 p.s.i.

Heating: 3 barrel zones, 2 die zones, total 11 kW. Five Ether-Wheelco controls on separate panels. Barrel machined for zoned water cooling, controlled manually or by instruments.

Output: Test results by manufacturers were: 1 in. by $\frac{1}{16}$ in. wall, plasticized p.v.c. tube—115 lb. per hour; same, rigid p.v.c. tube 80 lb. per hour; polystyrene moulding pellets 109 lb. per hour; polythene 1 in. by 3/32-in. wall tube 20 lb. per hour.

Other features: Take-off equipment driven by same variable speed gear with water bath or conveyor band.

REED, made by Reed Brothers Engineering, Ltd., Cuba Street, Millwall, London, E.14.

THIS company produces a 2-in. single-screw extruder which was described in *Plastics*, January, 1952, in the series "Machines for the Industry."

Screw and Cylinder: 2-in.-diameter special alloy steel screw, 14D long; 1½-in. pitch, twin start, diminishing depth; splined for easy removal. Cylinder is in three flanged sections with band heaters.

Drive: 7 h.p. variable-speed commutator motor, with induction regulator, giving stepless screw speeds of 15 to 70 r.p.m. Worm reduction gear, 30 to 1 ratio. Ball-type thrust bearing.

Heating: Band heaters, 3½ kW. total, Tem-Con thermostat control with indicating pyrometer. Control panel mounted on machine frame.

REIFENHAUSER, marketed in this country by Ed. Brand, Ltd., 9 St. Cross Street, Hatton Garden, London, E.C.1.

MANUFACTURED in Germany by A. Reifenhauser, this machine has been designed to deal with most compounds.

S.90/RG. Extruder

Screw and Cylinders: Nitrided single- or double-start screw, 90 mm. diameter, length normally 18 times diameter. Screw cooling provided for and specially shaped screws are manufactured for various materials

Die Head: An angle extrusion head is available which has a specially shaped flow channel. This head is particularly designed for covering wires, cables, ropes, tubes and strips. Heating is effected by two adjustable independent heating zones by means of electric resistance heating through band heaters; a straight line extrusion head is manufactured for the production of flexible and rigid tubes and for filaments, tapes, and profiles. This head possesses an air intake appliance which enables thin-walled flexible hose, hollow profile or similar products to be manufactured. A blowing head is made for the production of foils.

Drive: By 20 h.p. motor with V-belt connections through a safety start clutch.

Heating: The regulation of temperature for each heating zone is accomplished by means of individual thermocouples connected to an automatically controlled pyrometer. A special design of energy regulator is employed to reduce temperature fluctuation to the minimum. The measuring range for the temperature regulator is from 20-200° C. and the accuracy of regulation is ±1° C.

Output: Depending upon the material section, roughly between 88-176 lb. per hour.

Other features: The hopper has capacity for 1.4 cubic feet of material.

ROYLE, manufactured by John Royle and Sons, Paterson 3, New Jersey, U.S.A. Represented in England by James Day (Machinery), Ltd., Regent Street, London, W.1.

MANUFACTURING a range of extrusion machines, Royle were one of the pioneers in this field, being concerned with rubber extrusion. The company has had considerable experience in the thermoplastics field and one of its most successful productions has been the high-speed wire-covering machine, marketed in conjuction with feed-in and take-off equipment with tension-compensating devices. The three main machines made are No. 2, No. 3 and No. 4.

No. 2

Screw and Cylinders: Screw milled from forged steel, length, depth and lead being determined by the purpose for which the machine is to be used. The lands are hard surfaced, and the cylinder bore is 3¼ in.

Die Head: Holder head or hinged head.

Drive: 30 h.p. motor, using a V-belt connection which offers the advantage of being able to substitute sheaves, thus altering the stock-screw speed relationship to motor speed as desired.

Other features: A self-feed type hopper section is made as a separate unit of cast steel with provision for the circulation of the chosen heat control medium. It requires no stuffing mechanism and is so designed that stock, in many continuous forms, is taken into the hopper automatically. The ventilating space ring adjoining the hopper section provides for the inspection and disposal of any possible oil drip or stock escape which would otherwise act as a contaminant to the process or drive. Four methods of heating are available to give temperatures as low as 40° F. or as high as as 700° F.

No. 3

Screw and Cylinder: As above, cylinder bore being 4½ in.

Die Head: As above.

Drive: By 50 h.p. motor with V-belt connection.

Other features: As above.

No. 4

Screw and Cylinder: As above, cylinder bore being 6 in.

Die Head: As above.

Drive: By 75 h.p. motor with V-belt connection.

Other features: As above.

SHAW, made by Francis Shaw and Co., Ltd., Corbett Street, Ashton New Road, Manchester, 11.

SINGLE-SCREW extruders are made in a range of sizes covering 1-in., 1½-in., 2-in., 3-in., 4½-in., 6-in. and 8-in. diameter. It is interesting to note that Francis Shaw are pioneers in this field, having built their first screw extruder in 1879. The following general information applies to all sizes with the exception of the P.1 laboratory machine which is dealt with separately.

Screw and Cylinder: Normally of constant pitch, diminishing depth, length, 15D, small clearance between screw and liner, both made of hardened alloy steel.

Die Head: Various types are available, all designed for simplicity, minimum metal mass, small plastics-holding capacity, streamlined polished flow channels, uniform heating with accurate control, and easy dismantling and cleaning. Perforated baffle plate fitted at end of cylinder.

Drive: Variable-speed motor geared down to give appropriate stepless screw speed range, push-button speed control.

Heating: Cuff-type heaters in varying number of zones, depending on size, control by Ether-Wheelco proportioning instruments fitted in separate cabinet with switches, fuses, indicator lights, etc. Water cooling for feed box and screw, air or water cooling optional on cylinder.

Details for individual models include the following:

P.2

Screw: 2-in. diameter.

Drive: 13.5/4.5 h.p. motor.

Heating: Three barrel zones, 5 kW. total including die head.

Output: 60 lb. per hour approx. maximum.

Size: 5 ft. 3½ in. by 2 ft. 7 in., plus 4 ft. by 2 ft. 2 in. for instruments.

Weight: 45 cwt. net.

P.3

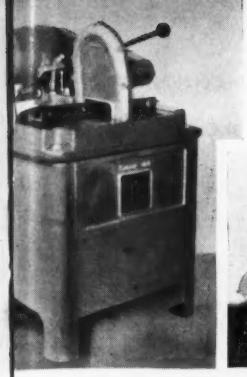
Screw: 3-in. diameter.

Drive: 20/6.7 h.p. motor.

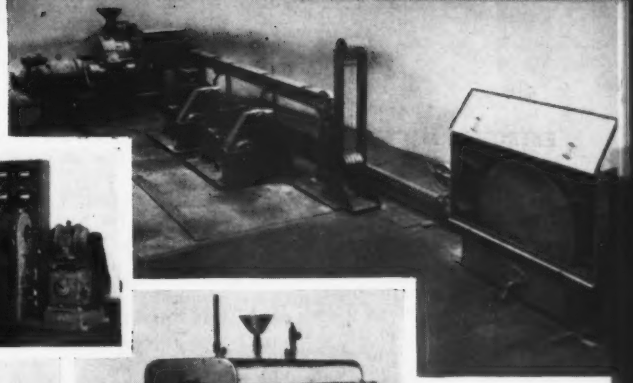
Heating: Three zones, 7 kW. total including die head.

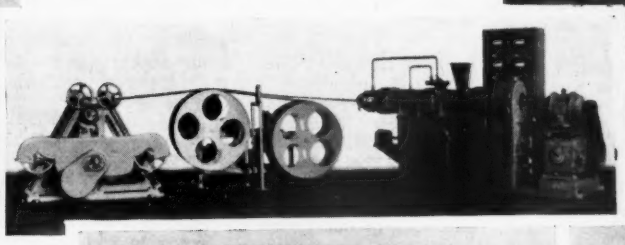
Output: 130 lb. per hour approx. maximum.

(*Continued on page 416*)

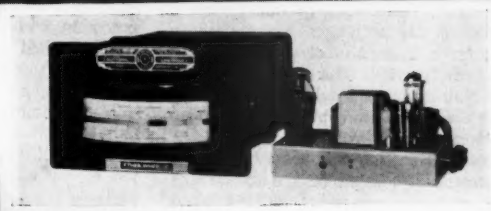


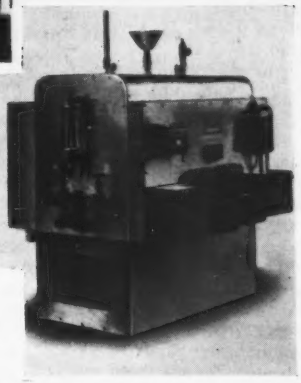
(Right) Bridge 4½" extruder, with ancillary equipment for wire and cable covering.
(Below) Berstorff cable covering plant, showing extruder, haul-off machine and re-wind stand.





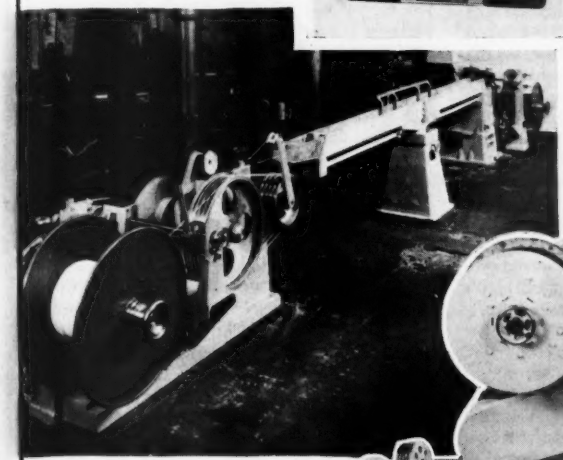
(Above) Speedipart machine for cutting off extrusions by E. & L. B. Pinkney Ltd.
(Right) Ether - Wheelco electronic temperature control unit, by Ether Ltd.



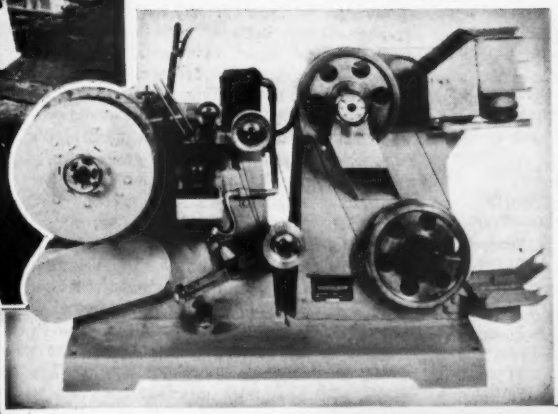


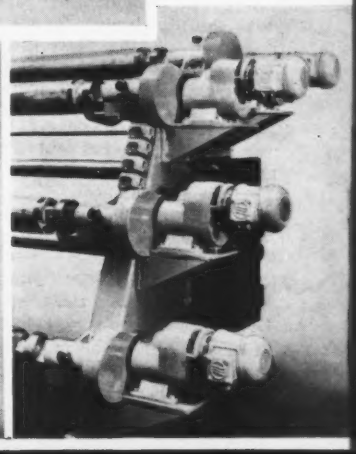
(Left) Bridge electrical operated oil heating cooling and circulatin unit.

(Below) Alquist unit fo re-winding extrusion at constant tension Marketed by Interna tional Corporation Ltd

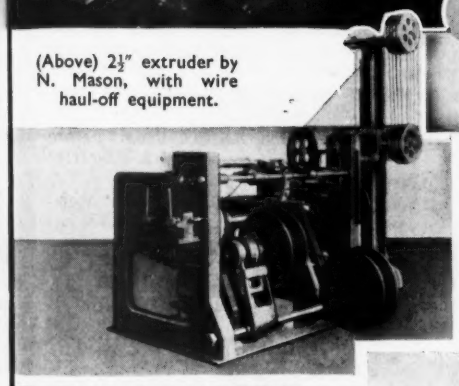


(Below) High speed fine wire haul-off made by N. Mason.

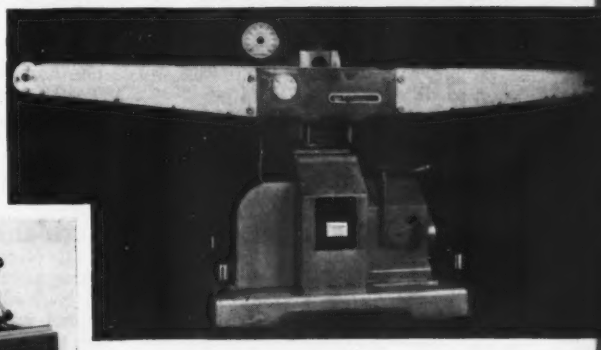


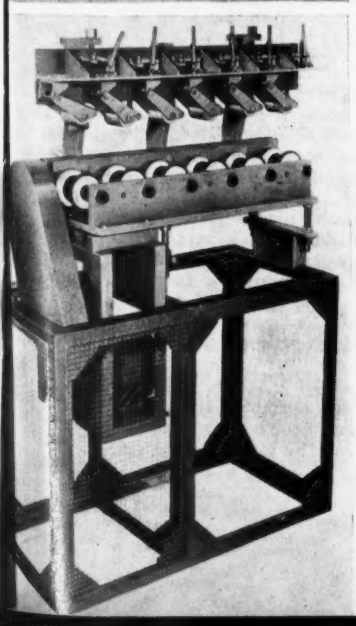


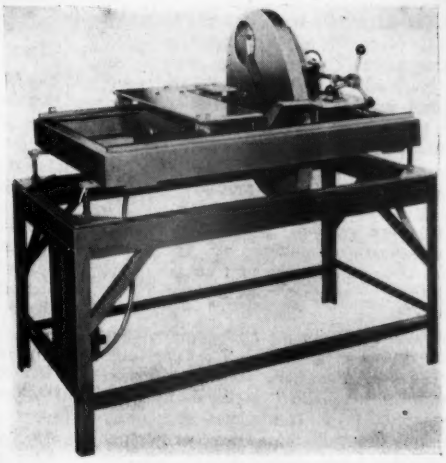
(Above) 2½" extruder by N. Mason, with wire haul-off equipment.



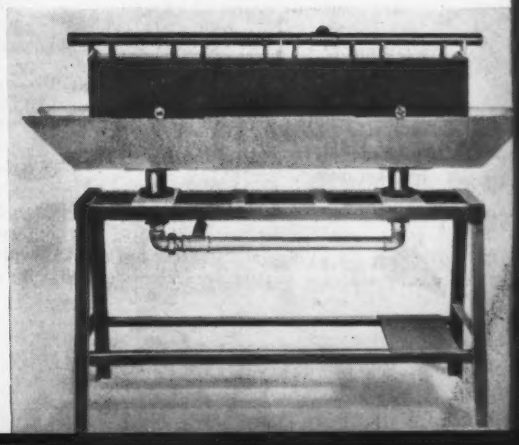
(Left) Davis-Standard take-up equipment for wire insulating (Finney Presses Ltd.).







(Above) Variable speed conveyor belt with speed indicator by N. Mason.



(Above) Cut-off device driven by 1 h.p. motor, made by R. H. Windsor Ltd.

(Left) Positive pulling device for rigid p.v.c. tube, by R. H. Windsor Ltd.

(Right) Water cooling bath manufactured by R. H. Windsor Ltd.

EXTRUSION MACHINES

(*Continued from page* 414)

Size: 6 ft. 10 in. by 2 ft. 9 in., plus 4 ft. by 2 ft. 2 in. for instruments.
Weight: 55 cwt.

P.4½

Screw: 4½-in. diameter.
Drive: 30/10 h.p. motor.
Heating: Four barrel zones, 15 kW. total including die head.
Output: 300 lb. per hour approx., maximum.
Size: 9 ft. 9 in. by 2 ft. 9 in., plus 5 ft. 6 in. by 2 ft. 2 in. for instruments.
Weight: 70 cwt.

P.I. Laboratory Extruder

Screw: 1-in. diameter, variable pitch.
Die Head: Alternatives include blank die plate for solid section die and mandrel for tubing, cross head for wire coating.
Drive: 1¼ h.p. motor running at 1,400 r.p.m. through infinitely variable-speed gear, finally through double reduction gear, giving screw speeds from 20 to 120 r.p.m.
Heating: Two cylinder heater bands 1.2 kW., four cartridge heaters for die head with flat heater for end. Three 4-in. indicating-controlling thermostats for cylinder and die zone regulation, feed box temperature indicator.
Output: 4.3 lb. minimum to 12.4 lb. max. per hour for material with S.G. 1.3.
Other Features: Varying types of conveyors for take-off equipment.
Size: 54.8 cu. ft. shipping dimensions.
Weight: 896 lb.

TROESTER, made by Paul Troester Maschinenfabrik, Hannover - Wülfel, Germany.

VERSATILITY of operation and ease of maintenance are the advantages claimed for these German machines which are made in four standard sizes: 30 mm. (1¼-in.), 45 mm. (1¾-in.), 60 mm. (2½-in.), and 90 mm. (3½-in.). Larger machines of 120 mm. and 150 mm. (4¾-in. and 6-in.) screw diameter are built to special order. The machine can use various lengths of screws by means of extra sections clamped to the barrel. The company has specialized in providing complete extruding and film-blowing equipment using their standard machines with special tube dies and vertical take-off equipment. Over 30 of these have been installed throughout Europe.

Machines are built in units, the drive housing, control panel and cylinder all being separate. The cylinder unit is mounted on rails and can be unclamped from the machine and moved clear of the screws to give easy access for cleaning or changing the screws.

U.P.30

Screws and Cylinder: Nitrided steel screws in five standard profiles 30 mm. diameter, 10D length or 15D with extra cylinder attachment. Cylinder mounted separately on unit running on rails for moving forward. Heater connections are by flexible leads or special interlocking pin connectors, surrounded for air-cooling.
Die Head: Various types, attached by bayonet clamp.
Drive: 2.2 h.p. motor, 1,450 r.p.m. through PIV infinitely variable gear. Screw speeds 15-90 r.p.m.
Heating: 3.8 kW. total, two cylinder zones, with separate heaters for extension and die head. Five station temperature control indicating instruments on separate panel.
Output: 4 kg. per hour for sections, 3-6 kg. for wire coating.
Size: 160 × 60 × 170 cm.
Weight: 800 kg. (net).

TRUDEX, made by Trudex, 45 Rue La Fayette, Paris, 9.

THE particular advantage of this French extruder is the ability to use material in powder form, instead of chips which are normally employed. This is specially important if unplasticized polyvinyl chloride extrusions are made, but polymers mixed with plasticizers, stabilizers, pigments, etc., can also be fed in. A number of special patented devices are fitted on the machine, including automatic measuring of temperature rise due to friction, automatic feed synchronized with screw speed, desiccation of material during working of the machine.
Screws and Cylinder: Two intermeshing contra-rotating screws 90 mm. (3½ in.) diameter, 700 mm. (28 in.) length, water-cooled; square section lands with interrupted discs near cylinder head for maximum work. Steel cylinder with two nitrided sleeves. Feeding, under pressure from hopper by volumetric screw variably controlled, suitable for powder premix.
Die Head: Holder for interchangeable dies connected to cylinder by a rapid locking method operated by two hand levers.
Drive: 15 h.p. three phase A.C. motor connected to speed variator with ratio 50 : 1. Transmission to reduction gear by V-belt.
Heating: Total 8½ kW., three cylinder zones, 1½, 2, and 2 kW.; 1½ kW. dieholder heater, separate die heater. Electronic thermostats with interrupters giving control to ½° C. Potentiometer regulator, 0-300° C. range. Multi-station indicator.
Other features: Optional air or water cooling of screw.
Output: 120 kg. (260 lb.) per hour average, 190 lb. max. (with unplasticized p.v.c.).
Size: 7 ft. 2 in. × 9 ft. × 5 ft. (219 × 121 × 150 cm.).
Weight: 2,500 kg. (5,555 lb.).

WINDSOR, manufactured by R. H. Windsor, Ltd., South Chessington, Surrey.

A SERIES of plastics extruders based on the principle of two or three intermeshing screws rotating in the same direction, invented by the Italian, Sr. Colombo, were first made in Italy by L.M.P. and have, since 1949, been manufactured by R. H. Windsor, Ltd., who have adapted their designs subsequently to meet developments of extrusion theory and practice (*Plastics*, November, 1949, p. 106). The screws which are in three sections in order to obtain gradual pressure build-up, act as a continuous positive pumping unit obviating the possibility of "surging" due to temperature fluctuations.

The thorough mixing and compounding action of these machines has not only favoured their use where heavy sections are required in "difficult" materials such as unplasticized p.v.c. (sometimes in powder form), but has made these machines popular with moulders and materials manufacturers for compounding, colouring and granulating. The large output of the R.C.200 means that it is almost exclusively employed for this purpose. A detailed description of this model appeared in the series "Machines for the Industry" in *Plastics*, October, 1951, p. 299.

R.C.65

Screws and Cylinder: Two alloy steel screws 16⅜ in. long in three sections of diameters 3.15 in., 3.35 in., 3.54 in. respectively to give three stages of compression. Barrel precision ground from heat-treated alloy steel attached to body by four tie rods bolted to frame and die plate, removable for cleaning or material change.
Die Head: Adaptor plate with heater suitable for collet-type die or swing-type die.
Motor and Drive: 5 h.p. A.C. commutator v.s. motor giving screw speeds infinitely variable from 4-13 r.p.m.
Heating: 3-5 kW./hour. Three Ether-Wheelco controlling pyrometers in separate cabinet. Optional water cooling.
Other features: Adjustable automatic feeding device metering amount of material fed to screws. Instruments include oil pressure gauge, ammeter, screw rev. counter.
Output: Over 65 lb./hr. according to material.
Size: 4 ft. 7 in. by 2 ft. 4 in. by 6 ft.
Weight: 2,240 lb.

R.C.100

Screws and Cylinder: Two screws 23 in. long in three sections 3.6 in., 3.85 in., and 4.1 in diameter respectively for compression stages; splined for easy removal of working section leaving thrust race and rear section undisturbed. Barrel attachment by hinged clamp-jaws eliminating tie-rods.
Die Head: Hinged adaptor plate for easy change.
Motor and Drive: 10 h.p. A.C. commutator v.s. motor, giving screw speeds infinitely variable from 6-18 r.p.m.
Heating: 7-8 kW. electric heaters with separate temperature control cabinet housing three Ether-Wheelco pyrometers. Optional water cooling.
Other features: Adjustable automatic metering feeder with spring-loaded clutch to prevent contamination from foreign bodies. Instruments include rev. counter and oil pressure gauge.
Output: Over 100 lb./hr.
Size: 6 ft. 11 in. by 2 ft. 10 in. by 6 ft. 8 in.
Weight: 4,908 lb.

R.C.200

Screws and Cylinder: Three intermeshing precision ground alloy steel screws, 32¾ in. long, three compression stages with 4.33 in., 4.625 in., 4.93 in., diameter respectively. Barrel of stainless, heat-treated alloy steel is in two sections to facilitate removal for cleaning and maintenance; attachment by four strain rods bolted to the frame and die head.
Die Head: Adaptor plate suitable for screwed-on pelleting die or collet-type section die.
Motor and Drive: 18 h.p. A.C. commutator v.s. motor, operating through two sets of spur and double-helical reducing gears and thence by planetary-type gear to the

screws. Screw speeds infinitely variable from 6-18 r.p.m. Cooled lubrication system for all gears.

Heating: 11-15 kW./hr. resistance heaters. Three Ether-Wheelco controlling pyrometers in separate cabinet.

Other Features: Feed regulator, oil gauge, ammeter and rev. counter. Take-off equipment for pelleting.

Output: Over 200 lb./hr.

Size: 8 ft. 2 in. by 3 ft. by 7 ft. 6 in. high.

Weight: 5,500 lb. plus 224 lb. for control cabinet.

ANCILLARY EQUIPMENT

Instruments

The Cambridge Instrument Co., Ltd., offer a roller gauge which is especially useful for sheet materials, providing a permanent record of sheet thickness; the machine will automatically record any slight variations and will further sound any necessary alarms.

Ether, Ltd., Tyburn Road, Birmingham, 24, market a series of instruments widely used with extrusion machines. The Ether-Wheelco electronic temperature indicator and controller gives accurate temperature control of barrels and die heads. These units are capable of extremely accurate temperature control.

The Tem-Con system, manufactured by P.A.M., Ltd., Guildford, Surrey, is applied to the heating barrel of extrusion machines. Type TC.16.C gives an accuracy of temperature of $\pm 0.2^\circ$ C.

Sunvic Controls, Ltd., 10 Essex Street, Strand, London, W.C.2, have for many years manufactured control measurement apparatus. These instruments are particularly valuable for apparatus where it is inconvenient or impossible to fit any type of thermostat.

Granulating Equipment

For certain types of powder manufacture, the compounds are extruded. The Girovinyle machine accepts continuous strips from the extruder and delivers granules ready for moulding. The Girovinyle granulator consists of two serrated rollers with mounted circular knives. The circular knives of the top roller work between the edges of the circular knives of the bottom roller with minimum clearance. The two rollers move in opposite directions to each other and push the material towards a number of further knives mounted on rotors in front of the rollers. This rotor is placed at 90° to the moving plastic strip and consists of several knives which can be mounted in various angles. The large double gear-box is airtight and determines the speed of rotation of the circular knives, which are in turn synchronized with the speed of the rotor knives. The gears of the machine are made as large as possible and calculated to give the maximum service and minimum of noise. All parts are mounted on ball-bearings.

Take-off Equipment

The design of take-off equipment varies considerably, depending upon the type of job that is required to be done. The basic principle is that material, having passed through the die of the extruder should be carried away from the machine under such conditions as will permit it to cool without loss in the shape of profile.

For normal strip extrusion it will probably be sufficient to install a continuous band machine. This is usually actuated by a motor, the speed of which is capable of close adjustment. By means of such apparatus the material leaving the die can be placed under tension by advancing the speed of the motor slightly faster than the rate of extrusion from the machine itself.

As an alternative to this method extrusions can be carried straight into a water bath and afterwards reeled up.

However, there are many instances where rather more elaborate instruments are required, particularly in the case of rigid tubes, where it is desirable that the extruded section passes first through a dimensioning head which will in effect take care of any slight variations in diameter as the tube leaves the extrusion die during the extrusion process. Methods of cooling such tube consist of passing water through a water bath but certain fabricators advocate the use of compressed air.

It is of the greatest help to place the tube under a tension and this can best be done by passing it through sets of profiled rollers, the upper portions of which press downwards with the aid of springs. By power driving one set of rollers the tube can be stretched and in this way accuracy of dimension can be controlled. An important point here is to ensure that the tubing is completely cold before passing through these rollers to avoid deformation.

The majority of extrusion machine manufacturers offer take-off equipment suitable for the machines in question.

For wire covering rather more complicated systems are employed. The covering of wire is usually carried out at high speeds and several factors have to be borne in mind. The wire which is on a drum passes through the die head and emerges, coated with the requisite amount of plastic material, after which it is eventually rewound on to another drum. The drum of uncovered wire is usually free running, the drum of covered wire being power driven. Compensatory devices must of necessity be included to overcome the gradual increase in speed of the wire as the diameter of the reel-up drum itself increases.

Inevitably variations occur in the tension which is being applied to the wire itself. Unless controlled these variations would seriously affect the quantity of extruded material coating the wire. For this reason special techniques have been evolved which usually consist of a series of weight or spring loaded pulleys. A good example of this type of apparatus is manufactured by the Royle Company, of America. N. Mason, of Luton, Bedfordshire, market a high-speed wire haul-off powered by two ¼ h.p. motors through special "Carter" hydraulic gears. The tension of the wire is automatically controlled by the wire itself and an automatic cut-out stops the machinery in the event of breakage of the wire. The apparatus is fitted with an 8-ft. tank for cooling purposes, for fine wire up to a maximum of 17,500 yards per hour.

The motors play a very important part in the successful operation of take-off equipment. The International Corporation, Ltd., 19 Ebury Street, London, S.W.1, market the Alquist winder which is suitable for re-wiring materials at constant tension despite the decreasing diameters of the bundle. This company also manufactures complete take-up sets if desired.

Carter Gears, Ltd., Bradford, Yorkshire, manufacture infinitely variable speed gears which find wide application in the plastics industry where cutting or reeling operations are involved.

Sentinel (Shrewsbury), Ltd., variable speed units are highly efficient in operation and can be made to give closely controlled output speeds. The essential feature of the mechanism lies in the double cone rollers rolling between the driving and driven discs to convert constant speed into a variable one.

It will be appreciated that take-off techniques vary enormously depending upon profile and material being extruded. For this reason, therefore, it is very desirable that the advice be sought of take-off equipment manufacturers in order that the correct apparatus may be supplied.

ANCILLARY EQUIPMENT MANUFACTURERS

Temperature Control Instruments

Cambridge Instrument Co., Ltd., 13 Grosvenor Place, London, S.W.1.
Ether, Ltd., Tyburn Road, Erdington, Birmingham, 24.
P.A.M. Ltd., Merrow, Guildford, Surrey.
Sunvic Controls, Ltd., 10 Essex Street, Strand, London, W.C.2.

Take-off and Wire Haul-off Equipment

Supplied by most manufacturers of extrusion machines—see pages 410-417.

Heater Bands

Elmatic Ltd., Colchester Avenue, Colchester Estate, Cardiff.
Elprod Ltd., 189 Wardour Street, London, W.1.

Variable Speed Gears

Allspeeds, Ltd., Accrington, Lancs.
Carter Gears, Ltd., Bradford, Yorks.
Sentinel (Shrewsbury), Ltd., Shrewsbury.

Granulating Equipment

Blackfriars Rotary Cutters, Ltd., New Bridge Street, London, E.C.4.
Industrial Plastics, Ltd., 16 Jermyn Street, London, S.W.1 (Girovinyle).
R. H. Windsor, Ltd., Chessington, Surrey.

Tube and Section Cutters

Iddon Brothers, Ltd., Leyland, Lancs.
J. C. Neville, Ltd., 34 Priests Bridge, London, S.W.14.
E. and L. B. Pinkney, Ltd., Grange Road, Middlesbrough.
R. H. Windsor, Ltd., Chessington, Surrey.

Winding Equipment

International Corporation, Ltd., 19 Ebury Street, London, S.W.1.

Embossing Rollers

T. G. Martin and Co., Old Colony House, Ridgefield, Manchester, 2.

MATERIALS FOR EXTRUSION

Notes on some of the special techniques called for in the extrusion of plastics materials, and a table of important properties of various commercially available compounds

IN the preparation of this section we have been guided by the materials manufacturers and have also taken into consideration the problems which we encounter in the course of our contact with materials users. For this reason our treatment of the materials field lies primarily in the presentation of notes prepared by several authorities on the special techniques required for extruding the various types of materials available. In this way it has been possible to prepare brief notes on p.v.c., cellulose acetate, cellulose acetate butyrate, polythene, P.T.F.E., polystyrene, nylon, casein and phenolics. It will, however, be appreciated that in the space available it has been only possible to draw attention to some of the most important points and for more specific information the reader is advised to make contact with suppliers who will be very pleased to give advice on the selection of suitable materials for any particular application.

This section is concluded by a table which schedules some important properties of a wide range of extrusion compounds. Here every attempt has been made to cover a wide field but again it should be stressed that only the materials manufacturers can give specific information, and that due to the lack of standard methods of test certain anomalies may occur.

We hope that the section as a whole will serve as a useful guide to present and potential users of extrusion compounds. The table includes the names and addresses of the various manufacturers and also schedules the various grades under their trade names.

POLYVINYL CHLORIDE

P.V.C. compounds for extrusion purposes generally fall into one of three classes: Electrical, General Purpose and Special Purpose. It is proposed to very briefly discuss the formulations of compounds for each of these three categories.

Electrical

Electrical extrusions are of two types—insulation and sheathing. In the former case the electrical properties of the compound are most important and it is usual to employ only polymers, plasticizers, stabilizers and colour pigments having the highest electrical properties. Fillers are seldom used in any significant quantity.

Di-2-ethyl hexyl phthalate commonly called di-octyl phthalate (DOP) is the most usual plasticizer. This is the best general purpose plasticizer currently available and can be obtained in a grade suitable for electrical purposes. For stabilization, basic lead carbonate is perhaps both the cheapest and the best, being satisfactory as regards heat and light protection and electrical properties. This material gives an opaque compound and where translucent or transparent compounds are required a metallic soap such as lead or cadmium stearate is employed. Often calcium stearate is used in conjunction with basic lead carbonate to enhance the heat stability as well as acting as a lubricant.

The hardness of the compounds is varied by altering the plasticizer content; the less plasticizer present, the harder the compound and the better the electrical properties. But on the other hand, flexibility, particularly at low temperatures is reduced as plasticizer content is decreased. Thus it is often necessary to make a compromise between electrical properties and the degree of flexibility required. For instance, a compound to be used for insulating Christmas tree light wiring would not require high electrical properties, but flexibility is essential. In such a case, a sheathing grade may be quite suitable.

Sheathing

The electrical requirements for sheathing compounds are not as stringent as for insulation grades, but more importance is attached to flexibility. Therefore, sheathing compounds are generally softer.

Furthermore, the lower electrical requirements permit greater latitude in choice of plasticizer. Tritolyl phosphate, di-2-ethyl hexyl sebacate and non-electrical grades of di-2-ethy hexyl phthalate are frequently employed. Sometimes plasticizer extenders such as chlorinated diphenyls, chlorinated waxes, both of which are cheap materials, or barium ricinoleate, which improves low-temperature flexibility, are used. A certain amount of filler may also be incorporated. In the United Kingdom the quality of both sheathing and insulation compounds is controlled by two major specifications. These are B.S.2004 and Ministry of Defence Specification DEF.9. In addition to these, a number of internal works specifications are in circulation.

General Purpose Extrusion Grades

This category covers a series of compounds varying in hardness, quality and price. They are loosely defined as general purpose because the same compound can frequently be employed for widely different purposes ranging from say decorative piping to industrial hose. They range widely in quality, but generally fall somewhat below the insulation grades. In this type of compound the usual vinyl plasticizers are employed such as di-2-ethyl hexyl phthalate, dialphanol phthalate, tritolyl phosphate, di-2-ethyl hexyl sebacate, and as the emphasis is often on cost, the cheaper plasticizer-extenders are used to a greater extent. This of course results in a lower-quality compound.

Fillers such as whiting (calcium carbonate) and china clay are often used, primarily to reduce costs. The inclusion of a filler leads to an apparent increase in tensile strength and modulus. This, however, is not evidence of reinforcement but solely due to the increase in the hardness of the compound. If the plasticizer content is raised to offset the hardening action of the filler, a general deterioration in physical properties occurs.

A wider range of stabilizers and colour pigments can be employed as the selection of suitable materials is not subject to electrical considerations.

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Special Purpose Extrusion Grades

These are compounds designed for one specific type of application. For instance, the compound may be formulated for service at very low temperatures and although ideal for this application may be of little use for other purposes.

Because of the exacting needs of some special purpose compounds, materials not usually employed in vinyl compounding are often used. For example, the use of carborundum powder as a filler to impart non-slip properties to extruded stair treads used in public vehicles may be mentioned.

Two special-purpose compounds which are becoming increasingly important are packaging film and rigid extrusion. Packaging film is normally extruded to a thickness of below 5 thou. and in order to achieve the right degree of stiffness the plasticizer content is invariably reduced. The actual amount of plasticizer depends on the thickness of the final film but as a general rule it is below 20%. Heat stability during extrusion is an important aspect and it is usual to incorporate a high proportion of stabilizer. The ready availability of tin stabilizers has made possible the formulation of compounds having the maximum clarity and freedom from physiological effects.

Rigid extrusion compounds need a very careful balance of ingredients. Although some compounds contain a few per cent. of plasticizer, approximately 5-10%, the trend is now towards a completely unplasticized compound. This necessitates a relatively high percentage of heat stabilizer; an increase in the lubricant content may be desirable to facilitate extrusion. The incorporation of some waxes and fillers of fine particle size also assists in this direction. There is some evidence to show that the inclusion of certain fillers tends to improve the impact strength of the compound.

Although it is not possible in a few words to discuss all aspects of compound design for extrusion, the above points indicate the general nature of the compounds used. The following table tabulates some of the more commonly used materials and indicates the effect on the properties of the compound.

MATERIAL	REMARKS
P.V.C. Resin Type	
Dispersion	Excellent electrical properties, heat stability and transparency.
Easy-processing ...	Similar to dispersion, but quicker and easier processing, particularly for rigids.
Emulsion	Cheaper, but having poorer electrical properties and transparency.
Plasticizers	
Di-2-ethyl hexyl phthalate	Excellent general-purpose plasticizer. Very good electricals, heat and light stability.
Di-alphanol phthalate	From C_7-C_9 alcohols. Cheaper than DOP. Slightly inferior properties.
Tritolyl phosphate ...	Flame-resistant plasticizer. Low volatility. Poor low-temperature characteristics and electricals.
Di-2-ethyl hexyl sebacate	Excellent low-temperature characteristics, coupled with good all-round properties, but expensive.
Polyesters	Increased resistance to migration, leaching and volatility. Expensive.
Chlorinated diphenyls	Plasticizer extenders having limited compatibility. Flame-resistant.
Barium acetyl ricinoleate	Plasticizer extender, limited compatibility, improved low-temperature properties.
Stabilizers	
Basic lead carbonate ...	Excellent heat and light stabilizer. Good electricals.
Dibasic lead phosphate	Excellent heat and light stabilizer. No tendency to gas when extruded in thick, rigid sections.
Calcium stearate ...	Transparent heat stabilizer. Often used to boost basic lead carbonate.
Lead and cadmium stearate	Transparent heat stabilizers.
Tin salts	Transparent heat and light stabilizers. Non-toxic but expensive.
Fillers	
Calcium carbonate ...	Most generally used filler. Fine particle size or surface treated types, aid processing and give better surface finish than china clay.
China clay	Filler, tends to give rough surface finish.

CELLULOSE ACETATE

Contributed by Courtaulds, Ltd.

THERE is a vast existing and potential field for cellulose acetate extrusions for normal and high acetyl materials. Precise tolerances and clean cross sections of extruded products are the result of correctly balanced conditions.

Manufacturers have given careful considerations to extrusion powder formulation and compounding. These powders are now given a double compounding to ensure complete uniformity as regards flow, and in the case of transparent materials a "gel"-free product. The acetate flake used for extrusion powders must be of the highest quality from the heat stability angle with uniform viscosity and good viscosity retention.

Heat stability is of paramount importance for these powders, with double compounding followed by final extrusion, which entails passage through three severely heated zones. It is known that cellulose acetate will not stand excessive temperatures for too long periods, although temperatures of 410° F. are used for extrusion, provided the material is moving continuously.

The conventional extruding machine consists of a hardened steel cylinder with a mirror finish, in which revolves a highly polished screw.

The screw is cored for circulating water at a controlled temperature, usually in the region of 70-80° F. for cellulose acetate material. A temperature gradient is maintained along the machine from 180° F-410° F. at the die. The temperatures in extrusion are critical, and slight variations cause "surging" at the die, which give uneven extruded sections. The hopper or throat temperature should not be too high, as this will prevent material feeding evenly into the confines of the screw and will result in uneven delivery.

Each grade of cellulose acetate extrusion powder needs some slight modifications to operating temperatures for successful running. For example, high acetyl grades need higher temperatures, in some cases as much as 65° F. higher at the die orifice.

Screw design is a matter of considerable controversy, and of the various accepted patterns there seems little to choose between in working the same materials. Clearance between liner and screw is held to .006 in. on the diameter, and excessive wear reflects itself in a fall in quality and output.

The length of the screws for normal cellulose acetate is usually 12-13 times the diameter, while for high acetyl 15 times the diameter is recommended. We have done experiments with 19 times length/diameter ratios for this specialized material, and much work remains to be completed. We have found that diminishing pitch, or diminishing depth give a satisfactory mixing action. A combination of diminishing pitch and depth appears to be a satisfactory profile for achieving homogeneity. There appears to be no great advantage with diminishing pitch screws, and for ease of manufacture diminishing depth is more frequently used. A diminishing depth screw combined with screw cooling gives a good mastication. The outer surface of material in the flutes moves over the material in the cooler confines of the screw, and the diminishing depth gives further movement of material as it is propelled to the outlet.

The diminution in pitch, or depth besides assisting in homogenizing also creates back pressure, and ensures an even flow into the head and die sections of the machine. Care must be exercised to give the correct rate of diminution; if this is too great the material will cause "clogging," and erratic feed at the throat.

We have used screws for cellulose acetate with single and double start scrolls, $\frac{1}{4}$ in. to $\frac{5}{16}$ in. depth, with a pitch varying from $1\frac{1}{2}$ in.-$2\frac{1}{4}$ in., and land lengths from $\frac{1}{8}$ in.-$\frac{1}{4}$ in. for 2-in. diameter screws. The use of a smear head or bulb heater at the end of the screw is advantageous for ensuring a completely homogeneous delivery of material to the die aperture.

A breaker plate acts as pressure stabilizer and arrests the rotary motion of the material as it is delivered from the screw. The homogenizing screens serve a dual purpose in stabilizing the flow and eliminating foreign matter from the product. When using these screens they must be incorporated at a convenient position for changing purposes. We use one 40-mesh and two 60-mesh gauges when using this type of screen.

Extrusion dies for tubing and rod are comparatively simple and inexpensive to manufacture, but dies for irregular sections often bear no relation to the actual shape required. The expense with this type of die is involved in the cut-and-try methods necessary to produce the desired sectional shape. The experience gained with irregular shapes is invaluable and each manufacturer builds up his own knowledge, and his previous experience soon gives him a lead when new sections are to be made. For example, where one part is thicker than another, the flow of the material has to be equalized by variation of the land lengths. The thicker the section, the longer the land required, and vice versa. When extruding a square section the die sides need to be concave to give a product with square corners and parallel sides; alternatively, if homogenizing screens are put immediately behind a square die, the flow is equalized and a good product is obtained. Again, when extruding C.A. strip with a plain slot, the extruded strip is not parallel-sided but convex. It was found that the most satisfactory method to stabilize the flow was by streamlining the die several inches from the orifice. By this method it is possible to produce strips with parallel sides, and by using detachable die plates controlled variation in strip thickness is also possible. The final size of the strip can be controlled by take-off speeds and nip rollers.

A must for successful extrusion is adequate reception and removal from the extrusion machine. The conveyor belt is a well-known method combined with "nip" rollers. For some sections cooling and collection in reels is sufficient. However, the conveyor and constant tension winders for strip and small-diameter rod collection need to be equipped with variable-speed drives to enable various sizes to be collected. As the material emerges from the extruder it is in a soft state and easily deformed, and in some cases it is set either by cold air blasts or extruding into a water bath at a controlled temperature. Other auxiliary equipment, such as "jigs," forming plates or tubes, is used to give exact cross-sections and sizes to extruded products, combined with controlled air blown through the mandrel, as previously mentioned. In the case of strip extrusion, the outside edges can be trimmed with revolving knives in a continuous operation at the end of the conveyor belt prior to reeling.

Cellulose acetate extrusion powders are being used for producing, among other items:—

(1) Transparent toothbrush containers. (2) Musical toys. (3) Flat strip for basketwork decorations. (4) Coverings for bus rails. (5) Screwdriver handles.

We have done considerable compounding of C.A. with single-screw extruders, but several problems present themselves with the addition of plasticized C.A. flake.

POLYTHENE

Contributed by Imperial Chemical Industries, Ltd.

ALL grades of polythene can be extruded easily on modern screw-type plastic extruders, but grade 2 is recommended. Whenever possible, the polythene should have incorporated in it an efficient antioxidant. The extrusion temperature is very important and greatly affects the quality and rate of production. For high output, the temperature should increase progressively from along the barrel to the screw. Since the viscosity of polythene is sensitive to temperature, this must be very accurately controlled at all places. A long screw with decreasing depth constant pitch characteristics is recommended and present opinion favours single start, although twin-start screws also give good results. There is much discussion on the desirable compression ratio, but 2-2.5 : 1 appears to be used widely and gives high output combined with good quality. Water cooling of the screw is also recommended for most purposes. Modern trends are towards one-piece barrels with no flanges and all attachments should be made with flanges or other devices kept as small as possible to avoid heat losses. The design of dies and extrusions should be such as to avoid dead spots, the aim being smooth flow without local pressure build up, except where desired, e.g. at breaker plates and filter packs. The internal volume of dies and extensions should be kept small. Breaker plates are normally used at the end of the screw and filter packs of various degrees of coarseness incorporated, their location and density depending on the application. Temperatures of extrusion depend on the operation and the characteristics of the machine. For grade 2, temperatures of about 150-160° C. are used for tubes and sections, while for wire covering temperatures of 200-260° C. are necessary. In film manufacture, where grade 7 is also used, temperatures of 150-160° C. are commonly used for the layflat variety and 260-300°C. for sheet. For paper coating, the highest possible temperature should be used and grade 7 is commonly preferred because of its easy flow characteristics in an operation requiring high linear speeds and good adhesion characteristics.

A most important factor in the extrusion of polythene is the cooling operation. For thin sections, rapid air cooling, cold drum or water quenching, may be used, although the rate of cooling and temperature of coolant can affect the properties of the product. For thick sections, cooling is very critical and must be adjusted by the use of air or hot, warm and cold water in order to achieve the minimum of strain in the article, e.g. thick-walled tube. For cable, there are the additional factors of reducing to the minimum air gaps at the conductor and preventing entirely voids in the body of the dielectric. For thick coatings, this may mean several passes through the extruder combined with cooling in a long water trough with very hot water at the die end.

POLYTETRAFLUOROETHYLENE

Contributed by Imperial Chemical Industries, Ltd.

POLYTETRAFLUOROETHYLENE, manufactured in this country under the name of Fluon, is remarkable for its inertness over a wide service temperature range from − 100°C. to 250° C., or even 300° C., which is greater than that of any other solid plastic. It is not attacked by any solvents, acids, etc., and within the given temperatures only fluorine and the molten alkali metals have been observed to attack it. Electrical properties are as good as or better than polythene over a wide frequency range. Fluon has poor flow properties and its behaviour at high temperatures makes normal extrusion techniques unsuitable.

Fluon may, however, be extruded from a modified screw or ram-extruder using temperatures of the order of 380° C.

on a special die. A screw-extruder is preferable, however, as the pelleting action of a ram-extruder tends to produce faults in the finished product.

The extruder is used as a pump, and forces the polymer through a conical die fitted with a torpedo, into a drawn-steel tube, which forms a die extension. It is first sintered in this tube at 380° C., then cooled to 100° C., and finally emerges as solid rod. Tube is made in the same way by attaching a long mandrel, which extends into the tube, on to the torpedo. A shrinkage takes place during cooling so that the dimensions of the die are 14% greater than those of the finished rod or tube. Temperatures and pressures are critical and, owing to the poor heat transfer of Fluon, extrusion rates are a few feet per hour.

For extrusion, it is advisable to use a mixture of raw and "baked" polymer, that is, polymer which has been previously heated without pressure to above 327° C. The use of such a mixture avoids any tendency of the polymer to "compact" in the extruder.

POLYTRIFLUOROMONOCHLOR-ETHYLENE

POLYMERS, containing fluorine and chlorine, have been developed in recent years by the Kellog Company in the U.S.A. and in Germany by Farbwerke Hoechst, A.G. Hostaflon is a polymer of trifluoromonochlorethylene made by Hoechst and sold in Great Britain by Lawfer Chemical Co., Ltd., 27 Regent Street, London, S.W.1. The characteristic features of Hostaflon are, in the first instance, high chemical resistance and mechanical strength over a wide temperature range, and it also has excellent insulating properties for the electrical industry. Considerably higher processing temperatures are required than those used for normal thermoplastic materials, but standard extrusion equipment can be adopted to handle it. Corrosive resistant materials such as high alloy steels, chrome nickel steels and hard-chromed steels should be used for equipment.

Great attention to cleanliness of equipment and surroundings is important in all processing. Every particle of dust of an organic nature decomposes if it reaches the moulding material because of the high temperatures. This leads to unattractive discoloration and bubble formation. As Hostaflon has unusually high electrical insulating properties and acquires an electric charge by the slightest mechanical motion, e.g., by shaking, it is quite possible that where the surroundings are not dust-free the dust of the air will be attracted electrostatically and will soil the material.

Rod, tubing, sheet and monofilament can be produced comparatively easily in lengths of many metres by extrusion. Extruders, like other equipment already described, are used at comparatively higher temperatures (260° C. to 290° C.), and corrosion-resistant steels, or nickel or chromed steels, should be used in the construction of cylinder, screw, nozzle, etc. Provision should be made for the separate heating and accurate temperature control, by thermostat, of various parts of the extruder. It is advisable to preheat Hostaflon powder to about 160° C-200° C. before filling it into the extruder. This obviates a strong heat contrast and the necessity to heat the powder from cold to the required temperatures inside the extruder.

By practical experience with a laboratory extruder the following temperatures, which are, of course, only a guide, were found satisfactory.

Filling zone	about 220° C.
Head end of cylinder	about 230° C.
Head	about 245° C.-250° C.
Nozzle	about 285° C.-290° C.

The Hostaflon issuing from the nozzle is clear, but in order to obtain optimum strength properties should be quenched by leading into cold running water only a few cm. away from the nozzle. This procedure is already well known in processing p.v.c.

The same precautions to avoid collapsing of tubes by blowing in air are to be observed here. The control of velocity of extrusion is also of importance. Where the velocity is high, it is possible to obtain thin wall sections, and very high extrusion velocities make it possible to spin threads with or without an inner hole. Foils can be produced on a round nozzle with larger diameter. By cutting open the tube and welding together, large surfaces may be obtained, which can be used to line chemical apparatus.

CASEIN

Contributed by Erinoid, Ltd.

IT is essential for the production of casein plastics having desirable properties that the moistened casein powder should be subjected to mechanical working while being held under the influence of heat and pressure. The screw extruder enables this homogenization to be achieved under conditions of almost complete control.

The screw is normally designed with a diminishing pitch to obtain compression and partial homogenization of the moist casein by the time it has reached the discharge end. The chamber in which the screw rotates is water cooled to prevent the premature homogenization of the casein on the screw due to the heat developed during the compression. If such plasticization takes place too far back on the screw, conveyance of the casein is reduced or may cease altogether.

As it is forced off the screw the casein passes through a fixed screen consisting of a perforated steel plate. This prevents the partially homogenized casein from rotating, thus enabling the screw to function as an efficient conveyor. Owing to the resistance imposed on the casein by the screen, pressure is built up in the casein mass, thus enabling further homogenization and mixing to take place.

Another fixed perforated steel screen is interposed in the flow of casein plastic just before it emerges from the nozzle. In order to allow the pressure exerted on the casein mass to increase steadily as it proceeds through the extruder this second, or nozzle, screen has smaller holes and is often backed by a wire gauze. Between the two screens is a chamber having a cylindrical or truncated cone shape. This chamber is heated by a water jacket, and the mechanical working imposed on the homogenizing casein mass also increases its heat content, enabling complete plastification to be achieved with the simultaneous elimination of ripple and other variable pressure effects.

The nozzle is maintained at the correct temperature for the efficient extrusion, satisfactory surface texture and correct size of the rod or other section.

By adjustment of screw size, characteristics and speed of rotation, and also by control of the temperature conditions obtaining in each of the three parts of the extruder, satisfactory homogenized and shaped sections are produced.

The plasticizer used for casein plastics is water. It is known that small variations in moisture content of casein mixes produce large variations in the flow of the casein through a given extruder under standard conditions of temperature, etc., as well as having a considerable influence on the texture and further processing properties of the extruded plastic.

Normally a single-screw extruder yields plain colours, but, with mixes containing orientable crystals or metallic leaflets together with the use of specially designed nozzles, special sheen effects can be obtained in rod sections. To achieve regular patterns of two or more colours in rods, tubes or discs an extruder having a corresponding number of screws operating in separate chambers and discharging into a specially designed common nozzle assembly is employed.

NYLON

Contributed by Imperial Chemical Industries Ltd.

THE extrusion of nylon is made more difficult than that of other thermoplastics because of its sharp melting point and low viscosity when molten. Further, it has a very small plastic range, although this varies according to grades, being completely absent in at least one type. However, the types of nylon offered for extrusion can be extruded into practically the whole range of the forms normally made in other thermoplastics. Most of the extrusion has been carried out on single screw machines, but in order to achieve the best results, it has been necessary to develop a machine specially suited to deal with nylon. All the nylons used for extrusion are hard, horny materials which do not soften appreciably below the melting point, which is high. Little mechanical work is done in the extruder and therefore all the heat has to be applied externally. The heat transfer characteristics are also poor. The preferred design of extruder has a shallow screw of the decreasing-depth single-start type. It is 15 to 20 diameters long and incorporates a constant-depth, constant-pitch metering section at the end usually for the last three flights. The bulk of the compression ratio is applied as the section of change to the metering section, the overall ration being about 3 : 1. Temperature conditions are chosen so that the nylon is completely molten at the metering section. The barrel of the extruder is in one piece to avoid cool spots due to flanges and is electrically heated with the closest possible temperature control. Internally, the design is such as to eliminate dead spots and overheating, particularly in adaptors and dies. The latter are also designed to prevent heat losses and the internal volume kept small. The clearance between screw and barrel is kept as small as possible. No water cooling is permissible in the screw. Its use may cause screw seizure and probably fracture.

Extruders not specially designed can be used provided the screw is of adequate length and the necessary heat available. In this case, the use of an extension in which melting occurs is advised using a bank of screens at the die end to achieve satisfactory back pressure. High temperatures on the barrel with low temperatures on the die have also been used, but neither of these methods is as satisfactory as that described earlier.

For wire covering, horizontal extrusion is used and for best results the special machine should be used. The die and crosshead are kept as small as possible and should be of the pre-centred type. A filter system of metal screens is fitted at the end of the screw to prevent unmelted material going forward to the die and to remove any accidental contamination due to foreign matter. Either tubing or forcing methods may be used, but the tubing method with vacuum applied to the die gives very good results. High draw-down can be used and, in fact, is normal because the usual thickness applied in the sheathing application is 0.004 in.-0.006 in. The coated wires are cooled directly in cold water. Highly efficient and accurately controlled haul-off gear is required because of the high linear speeds used.

Strips and films can be made by extrusion directly downwards into cold water. Tubes and rods are made by more conventional methods, but nylon compositions with a softening range and high melt viscosity are necessary to give the best results.

POLYSTYRENE

Contributed by Monsanto Chemicals Ltd.

THE characteristics of polystyrene, particularly excellent electrical properties and good chemical resistance, have created a demand for it in the forms of sheet, tube and profile sections. Extrusion colouring to give a wide range of homogeneous colours for subsequent injection moulding is another important process.

Equipment

The application of extrusion processing to polystyrene is a comparatively recent development and, accordingly, the technique has had the benefit of experiences gained on other thermoplastics and rubber. As may be expected in these circumstances, the first attempts were made with modified machines and it was some time before specially designed screws and machines made their appearance.

The single screw type of extruder is used predominantly for polystyrene and it is probably in the design of screw that the extrusion technique for polystyrene differs most from other thermoplastics. Single screws are cheaper, easier to maintain and have a relatively higher output. A single flight throughout the length of the screw is generally more satisfactory than double flights, or combinations of the two. The screw should have a compression ratio of 3 : 6 to 1 by either decreasing pitch or increasing the root diameter. Clearance between lands and cylinder should be less than .005. Chromium plating of the liner bore is not generally desirable, but it may be used on the screw.

The cooling of the screw affects output and the occurrence of surging, as it will discourage the material from sticking to the screw and backing up the feed. The cooled section should extend for a short distance beyond the hopper zone; the use of the closed-system circulation with controlled temperature for the water shows good promise, particularly for large machines.

The incorporation of a torpedo is necessary and leads to better extrusions, and the elimination of surging effects. A breaker plate is also recommended for increasing turbulence in the material. Where scrap material is being processed, the incorporation of a filter pack of two 60-mesh screens placed at right angles is necessary.

Dies should be designed approximately 10%-15% oversized, to allow for draw-down, and the land should be approximately 6-10 times the thickness of the extruded parts. The length of the land influences back pressure, surface finish and the holding of dimensional tolerances.

The take-away and cooling equipment can be of the conventional type for thermoplastics.

Processing

As there are no plasticizers or fillers present in polystyrene, the main function of the extruder is plasticizing rather than compounding, except, in some cases, the dispersion of colourants. No pre-heating of the material is necessary.

General purpose polystyrene's excellent thermal stability allows greater tolerance with operating temperatures and, in fact, it can be processed at higher temperatures and faster than other thermoplastics, without danger of decomposition.

Cylinder temperatures of 220° C.-240° C. and die temperatures of 200° C.-220° C. are suggested as a starting point. Speeds may vary over a wide range of 35-120 r.p.m.; in excess of this no significant increase in throughput is obtained. For difficult extrusion, the addition of an internal lubricant, such as zinc stearate, in a concentration of 0.1-0.5% should improve output.

As practically every extruder has its own distinctive variables, an indication of precise operating conditions is not possible: however, if screw speed, temperatures, etc., are adjusted so that the temperature of the material emerging from the die is 190° C.-200°C., a satisfactory extruded product should be achieved.

When dimensions and finish are stabilized, the material temperature must be maintained within 5° C. during the run.

The so-called alloy-styrene will generally extrude at faster rates than the general-purpose material, but it is particularly important to ensure that materials are free from moisture, otherwise a dull surface and blisters will result. Stock temperatures of these materials must remain below 275° C. to prevent degradation and imperfect extrusion.

Large sections tend to skin-harden while the interior is still soft, due to the low thermal diffusion of polystyrene; further cooling may then create vacuum bubbles. This troublesome feature is eliminated by graduated cooling rates, commencing with a warm water bath, or air jets, and accomplishing final set-up in a cold bath.

The efficiency of the take-off equipment is most vital. Buckling, warpage, bowing and distortion of the section will be encountered unless uniform cooling is arranged.

General-purpose polystyrene sections are less amenable to guillotine cutting and other cut-off methods than other thermoplastics, owing to its susceptibility to cracking and fracture. However, if the section is cut whilst warm, or a hot knife is used, the operation can be accomplished successfully. The impact-type styrenes present little difficulty in this respect.

Rubber-covered draw rolls with variable speed control are used to carry away the cooled section at a uniform rate.

Special auxiliary equipment to the take-off is necessary for such operations as pelletizing and orientating monofilaments.

PHENOLIC MATERIALS

THE extrusion of phenolic materials is possible by the use of a machine which has some resemblance to the extruder used for normal thermoplastic materials. In place of the screw normally employed, is a ram working within the barrel, the latter being divided into several clearly distinct zones of heat. The phenolic material is fed into the barrel by means of a hopper and successful extrusions can be obtained at rates ranging from 4½-5 inches per minute for a tube of 4¾ in. diameter, up to 10 inches per minute for a 1-in. diameter tube.

When starting up the machine the first few strokes on the ram merely compress the material. Thereafter the ram is moved backwards and forwards at a sufficient speed to ensure that no material is left in the barrel long enough to become thermoset. For this reason only a specially easily flowing material can be used, of a more expensive type than would be normally employed for moulding purposes.

A typical temperature range over three zones of the barrel would be 50° C. (Zone 1), 130° C. (Zone 2) and 190° C. (Zone 3). The pressure exerted by the ram varies from 250 lb. to 1½ tons per square inch and an important feature of the process is that having completed its stroke the ram should be returned to the start position again in the shortest possible time. Only by this method can the material in the barrel be kept practically in a state of permanent motion and thus a thermoset mass avoided.

As already mentioned, a special type of material is required for the process, and one of the interesting features of the technique is that impact strength is frequently found to be as much as 50% higher than in the case of an identical moulding compound. The reason for this is ascribed to the possible orientation that takes place during the extrusion process.

CELLULOSE ACETATE BUTYRATE

CELLULOSE acetate butyrate is supplied in the form of pellets for continuous extrusion without the use of solvents, into strips, rods, tubes, mono-filaments, sheeting, and various sections. The absence of solvents with this material is claimed to give an important advantage to the extruder in that shrinkage due to solvent evaporation is eliminated. In this way extruded sections can be held to very close tolerances and any necessity for after-treatment is avoided.

Extrusion temperatures are in the order of 160-230° C., depending upon the grade of material employed.

The basic technique called for in the extrusion of this material is similar to that employed for polythene and p.v.c. For example, a 3½-in. Royale machine with a 36-in. screw could work to a capacity of about 150 lb. It is necessary, however, to ensure that the material is completely dry immediately before use and for this reason it is customary to inject through the base of the hopper compressed air at a temperature of between 65-75° C. The drying capacity of such a hopper should be approximately 50% greater than the capacity of the extrusion machine in pounds per inch.

Various ancillary equipment has been devised to perfect the extrusion of this material and for full details and diagrams the reader is referred to publications issued by the Kodak Company, Ltd., and to two articles published in *Plastics* for December, 1952, and January, 1953.

SILICONE RUBBERS

Contributed by Midland Silicones Ltd.

These notes refer to Silastomer silicone rubbers manufactured by Midland Silicone and do not necessarily apply to other types.

SILICONE rubber stocks as supplied are fully compounded and ready for processing. The methods of handling and the equipment required are similar to those used in processing organic rubbers. The principal differences in handling are owing to the fact that the basic silicone polymer is built on an inorganic skeleton of silicon-oxygen-silicon atoms which does not contain any points of unsaturation. The cross-linking required for the development of elastic properties is initiated by a vulcanizing agent which is activated by heating the stocks.

The initial cure (commonly referred to as vulcanization) is carried out in a press or steam autoclave. Final curing is brought about by further heating in an air-circulating oven at temperatures up to 250° C.

THE DEVELOPMENT OF THE PLASTICS EXTRUSION PROCESS

(*Continued from page 407*)

some indication of the potentialities of extrusions in many industries.

An important trend during recent years has been the increasing recognition of plastics as complementary raw materials for industry. P.v.c. and polythene extrusions are now being widely utilized for their inherent characteristics, such as self-colour, lightness, chemical resistance and durability.

The recent introduction of a range of high-capacity extrusion machines has promoted the manufacture of large sections which are proving to be of great value to the chemical industry.

It is now possible to visualize extrusions ranging from monofilaments of 0.001-in. diameter to tubing with a circumference of several feet. Monofilaments are already being used in woven fabrics and large-bore tubings are extensively employed.

There are also important application in agriculture, where enormous quantities of plastic water piping are needed.

In the field of packaging, too, there are many potential uses for large extruded sections, as they could be employed in the manufacture of drums and other containers.

The potentialities of plastics in the building industry have not been fully explored. It is probable that plastics and metal will be complementary to each other, for many plastics extrusions are used in conjunction with metal components.

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TABLE OF IMPORTANT EXTRUSION C

Due to various methods of test that have been employed to arrive at the figures given below, certain anomalie arise item concerned. The figures quoted are those supplied to us by the materials manufacturers and the reade shou obtained by contacting th indi

MANUFACTURERS' NAMES AND ADDRESSES	MATERIAL	TRADE NAMES AND GRADE NUMBERS	GENERAL						
			Specific gravity	Softening point	Maximum service temperature	Minimum service temperature	Water absorption	Heat Ageing loss in weight	Extru temp cu
			°C.	°C.	°C.	°C.	mg.	%	°C
Bakelite Ltd. 12–18, Grosvenor Gardens, London, S.W.1.	Polyvinyl chloride	Vybak VN. 350	1.41–1.46	—	—	—	6–8	1.5–2.0	—
	Polyvinyl chloride	Vybak VN. 207	1.38–1.43	—	—	—	32–42	2.0–2.5	—
	Polyvinyl chloride	Vybak VN. 709	1.34–1.38	—	—	—	27–35	1.5–2.0	—
	Polyvinyl chloride	Vybak VN. 314	1.27–1.30	—	—	—	2–3	1.5–2.0	—
British Geon Ltd. 21, St. James's Square, London, S.W.1.	Polyvinyl chloride	GF 2073, filled dielectric	1.38	—	—	—	22	—	17
	Polyvinyl chloride	GA 4075, sheathing and G.P.	1.27	—	—	—	9	0.6	17
	Polyvinyl chloride	GC 4213, crystal extrusion	1.28	—	—	—	20	3.5	175–
	Polyvinyl chloride	GA 2002, dielectric	1.34	—	—	—	9	1.0	18
	Polyvinyl chloride	GA 2011, dielectric	1.32	—	—	—	8	0.5	18
	Polyvinyl chloride	GA 2374 H.T. dielectric	1.29	—	105	—	8	0.32	17
	Polyvinyl chloride	RA 122, rigid grade	1.54	—	60	—	6	0.14	19
N.B.—Power Factor measured at 800 cycles.	Polyvinyl chloride	52,077/214, packaging film	1.29	—	—	—	10	0.7	17
British Resin Products Ltd. 21, St. James's Square, London, S.W.1.	Phenolic	Rockite	1.34	—	+60	−60	80–140	—	135–
	Cellulose acetate	Cellomold 6604.E	1.35	60	+30	−10	10	—	15
	Polystyrene	Distrene 500	1.05	93	+50	−25	Nil	—	170–
	Polystyrene	Distrene 400	1.05	91	+50	−25	Nil	—	170–
Courtaulds Ltd. Little Heath, Coventry.	Cellulose acetate	E.10 M, for thin sections and film	1.31	—	—	—	3.0	3.0–4.0	20
	Cellulose acetate	E.11, MH, M, MS, S, S2, general-purpose	1.31–1.29	—	—	—	4.5–2.5	1.5–4.5	21
	Cellulose acetate	E.11/80, flexible	1.28	—	—	—	3–5	7.5	17
East Anglia Plastics Ltd. 52, Brook Street, London, W.1.	Cellulose acetate	Medium/soft flow	1.28	49	35	−10	2.5	3.3	15
	Cellulose acetate	Medium flow	1.29	54	40	−5	2.5	3.0	16
	Cellulose acetate	Hard flow	1.29	64	50	0	2.5	2.5	18
	Polyvinyl chloride	Filled	1.46	—	60	−10	0.17	2.0	160–
	Polyvinyl chloride	General-purpose	1.38	—	70	−30	0.17	2.2	160–
	Polyvinyl chloride	Dielectric	1.37	—	70	−25	0.1	2.16	160–
Erinoid Ltd. Lightpill Mills, Stroud, Gloucestershire.	Cellulose acetate	Medium grade	1.28–1.35	56–65	50	—	3.5	3.0	140–
	Polystyrene	H.S. grade	1.28–1.35	56–65	50	—	3.5	3.0	140–
	Polystyrene	Improved impact	1.04–1.07	85–90	70	0	0.2–0.4	—	160–
	Polyvinyl chloride	Flexible	1.2–1.36	—	—	−25	2.0–4.5	4.0–4.5	100–
	Polyvinyl chloride	Semi-rigid	1.3–1.45	—	—	0	1.0–2.0	2.0	100–
	Polyvinyl chloride	Rigid	1.35–1.6	45–50	40	—	0.5	0.5	100–
	Polyvinyl chloride	Unplasticized	1.35–1.6	70–85	60	—	0.2	—	100–
Hercules Powder Co. Ltd. 140, Park Lane, London, W.1.	Polyamide	Akulon M2A	1.13	220	100	−60	—	—	250–3
	Polyamide	Akulon M2	1.13	220	100	−60	—	—	250–3
	Polyamide	Akulon M10	1.13	220	100	−60	—	—	240–2
	Polyamide	Akulon B2	1.13	220	100	−60	—	—	230–3
Imperial Chemical Industries Ltd. (Plastics Division) Black Fan Road, Welwyn Garden City, Herts.	Nylon	BA	1.09	215	—	−60	0.43*	—	285
	Nylon	DB	1.08	170	—	−60	0.5*	—	285
	Polythene	Alkathene 2	0.92	94	70	−60	0.15*	Nil	210
	Polythene	Alkathene 7	0.92	92	70	−40	0.15*	Nil	185
	Polythene	Alkathene 20	0.92	88	65	−30	0.15*	Nil	175
	Polyvinyl chloride	Welvic 75/13	1.34	—	70	−30	0.5*	1.0	185
	Polyvinyl chloride	Welvic 79/36	1.35	—	70	−35	0.5*	1.0	180
	Polyvinyl chloride	Welvic VK	1.30	—	70	−40	0.5*	1.0	185
	Polyvinyl chloride	Welvic VT	1.28	—	70	−45	3.5*	1.0	165
	Polyvinyl chloride	Welvic 79/78	1.30	—	70	−55	3.5*	1.0	165
	Polyvinyl chloride	Welvic 76/86	1.45	90	60	—	3.5*	Below 1.	180
	Polyvinyl chloride	Welvic HR	1.43	66	45	—	3.5*	Below 1.	180
	Polyvinyl chloride	Welvic VS/3	1.30	—	70	−40	0.5*	1.0	175
	Polyvinyl chloride	Welvic CT/2	1.34	—	70	−25	3.5*	1.0	160
	Polyvinyl chloride	Welvic XX	1.26	—	70	−55	3.5*	9.0	160
N.B.—Power Factor measured at 10⁶ cycles.	Polyvinyl chloride	Welvic 60Z2	1.28	—	70	−55	0.5*	9.0	175
Kleestron Ltd. West Halkin Street, London, S.W.1.	Polystyrene	General-purpose	1.054	87–92	77	—	.03–.04	0.1–2.0	190–23
Kodak Ltd. Kingsway, London, W.C.2.	Cellulose acetate/butyrate	Tenite II, 265E	1.17–1.22	135–175	—	—	1.2–2.2	0.1–1.0	169–23
	Cellulose acetate/butyrate	Tenite II, 268E	1.17–1.22	135–175	—	—	1.3–2.2	0.1–1.9	169–23
	Cellulose acetate/butyrate	Tenite E, 435E	1.17–1.22	135–175	—	—	1.4–2.2	0.1–1.7	169–23
Lawfer Chemical Co. Ltd. 27, Regent Street, W.1.	Polytrifluorochloroethylene	Hostaflon	—	110	290	—	—	—	260
Midland Silicones Ltd. 19, Upper Brook Street, London, W.1.	Silicone rubber	Silastomer 152	1.22	—	200	−62	0.1	—	30
	Silicone rubber	Silastomer 50	1.21	—	200	−62	0.1	—	30
N.B.—Abrasion resistance measured by Dupont—Croydon test.	Silicone rubber	Silastomer 80	1.23	—	200–300	−62	0.1	—	30
	Silicone rubber	Silastomer 261	1.21	—	200	−90	—	—	30
Monsanto Chemicals Ltd. Victoria Station House, London, S.W.1.	Polystyrene	Lustrex L	1.05	90–94	80	−60	.03–.04	—	150–25
	Polystyrene	Lustrex MI	1.05	90–91	80	−60	.03–.04	—	150–25
Vinatex Ltd. Devonshire Road, Carshalton, Surrey	Polyvinyl chloride	Vinatex XH/53GP	1.38	—	75	−20	—	—	—
	Polyvinyl chloride	Vinatex PR/53 petrol-resist	1.55	—	85	−20	—	—	—
	Polyvinyl chloride	Vinatex XXR/14, rigid	1.45	50	—	—	—	—	—
	Polyvinyl chloride	Vinatex IH/53 dielectric	1.4	—	85	−30	—	—	—
	Polyvinyl chloride	Vinatex IG/53 dielectric	1.35	—	80	−40	—	—	—
	Polyvinyl chloride	Vinatex IS/53 dielectric	1.3	—	65	−45	—	—	—

* All figures for water absorption give percen

ON COMPOUNDS AND THEIR PROPERTIES

omaile arise. Where possible, and where we have been informed, variations in testing technique are noted for each reade should note that this list is by no means exhaustive. Details of the full range of compounds available can be ng th individual manufacturers.

	PROCESSING		MECHANICAL				ELECTRICAL			CHEMICAL				
Heat Ageing loss in weight	Extrusion temperature	Decomposition temperature	Tensile strength	Abrasion resistance	Young's modulus	Elongation at break	Volume resistivity	Dielectric strength	Power factor at 1,000 cycles	Resistance to acids	Resistance to alkalis	Resistance to benzene, toluene, etc.	Resistance to petrol, white spirit, etc.	Resistance to chlorinated compounds
%	°C.	°C.	lb.-sq. in.		lb.-sq. in.	%	ohms-cm.³	volts per mil.	%					
1.5–2.0	—	—	3,100–3,600	Good	2,000–2,300	275–325	5×10^{13}–20×10^{13}	400–500	—	Good	Good	Poor	Poor	Poor
2.0–2.5	—	—	2,000–3,400	Good	830–1,230	280–330	1×10^{19}–5×10^{19}	350–480	11–12	Good	Good	Poor	Poor	Poor
1.5–2.0	—	—	2,600–3,100	Good	1,000–1,400	310–360	—	290–350	—	Good	Good	Poor	Poor	Poor
1.5–2.0	—	—	3,100–3,500	Good	1,500–1,800	300–350	1×10^{13}–10×10^{13}	350–450	11–12	Good	Good	Poor	Poor	Poor
—	170	—	2,100	—	—	300	4×10^{12}	400	0.07	Fair	Fair	Fair	Fair	Fair
0.6	170	—	2,100	—	790	360	3×10^{12}	400	0.08	Excellent	Excellent	Fair	Fair	Fair
3.5	175–180	—	3,000	—	1,600	280	2×10^{14}	—	—	Fair	Good	Fair	Fair	Fair
1.0	180	—	3,400	—	2,000	285	1×10^{15}	440	0.1	Excellent	Excellent	Fair	Fair	Fair
0.5	180	—	3,400	—	2,400	245	4×10^{14}	400	0.09	Excellent	Excellent	Fair	Fair	Fair
0.32	170	—	2,500	—	1,100	350	1×10^{13}	360	0.09	—	—	—	—	—
0.14	190	—	5,000–6,000	—	—	Below 10	75×10^{15}	375	0.012	Excellent	Excellent	Good	Good	Good
0.7	175	—	3,600	—	2,700	275	1.4×10^{14}	400	0.08	Excellent	Excellent	Fair	Fair	Fair
—	135–175	Over 300	7,500 approx.	Good	1×10^{6} approx.	5 approx.	1×10^{12}	250	0.05 approx.	Good	Poor	Good	Good	Good
—	150	Over 150	3,000–4,000	Fair	3×10^{5} approx.	20 approx.	10^{10}–10^{12}	450	—	Poor	Poor	Poor	Good	Poor
—	170–180	Over 200	3,600–4,500	Fair	3.5×10^{5} approx.	8–20	—	500	0.0025	Excellent	Good	Attacked	Attacked	Attacked
—	170–180	Over 200	4,500–5,500	Fair	—	2–4	—	—	—	Excellent	Good	Attacked	Attacked	Attacked
3.0–4.0	205	280	4,000–5,000	—	—	40–50	—	—	—	Poor	Poor	Good	Good	Attacked
1.5–4.5	215	280	5,200–3,500	—	—	25–50	—	—	—	Poor	Poor	Good	Good	Attacked
7.5	170	280	2,500	—	—	40–50	—	—	—	Poor	Poor	Good	Good	Attacked
3.3	150	Over 200	3,000	—	—	38	5×10^{11}	300	—	Fair	Poor	Fair	Fair	Good
3.0	160	Over 200	3,500	—	—	35	6×10^{11}	300	—	Fair	Poor	Fair	Fair	Good
2.5	180	Over 200	4,500	—	—	30	7×10^{11}	300	—	Fair	Poor	Fair	Fair	Good
2.0	160–180	Over 210	2,000	—	1,300	250	1×10^{11}	350	—	Good	Good	Poor	Poor	Fair
2.2	160–175	Over 210	2,800	—	1,800	250	2×10^{12}	370	—	Good	Good	Poor	Poor	Fair
2.16	160–180	Over 210	3,000	—	2,000	225	2×10^{14}	390	—	Good	Good	Poor	Poor	Fair
3.0	140–200	Over 200	3,000–4,000	Fair	—	30 approx.	5×10^{12}–3×10^{13}	450–550	0.04–0.09	Fair	Poor	Good	Good	Fair
3.0	140–200	Over 200	3,000–4,000	Fair	—	30 approx.	5×10^{12}–3×10^{13}	450–550	0.04–0.09	Fair	Poor	Good	Good	Fair
—	160–220	Over 250	4,000–6,000	Fair	3×10^{5}–4×10^{5}	3–15	10^{13}	400	0.0002–0.01	Good	Excellent	Poor	Poor	Poor
4.0–4.5	100–190	Over 180	1,500–2,500	Good	—	250–350	5×10^{9}–2×10^{13}	275–350	0.05–0.10	Good	Fair	Fair	Fair	Poor
2.0	100–190	Over 180	2,500–4,000	Good	—	100–200	10^{12}–10^{14}	350–400	0.01–0.04	Good	Good	Fair	Fair	Poor
0.5	100–180	Over 180	5,000–6,000	Good	—	20	5×10^{14}	450–550	0.01–0.03	Excellent	Good	Good	Good	Poor
—	100–180	Over 180	6,500–8,500	Good	4.4×10^{12}–6.6×10^{12}	10	10^{13}	450–550	0.01–0.03	Excellent	Excellent	Good	Good	Poor
—	250–300	300–310	37,000	—	—	300	2.6×10^{5}	450	0.07	Fair	Excellent	Good	Good	Good
—	250–300	300–310	37,000	—	—	300	2.6×10^{5}	450	0.07	Fair	Excellent	Good	Good	Good
—	240–290	300–310	31,400	—	—	300	250	130	0.15	Fair	Excellent	Good	Good	Good
—	230–300	300–310	38,000	—	—	300	2.6×10^{5}	450	0.07	Fair	Excellent	Good	Good	Good
—	285	330	8,500	—	—	—	10^{14}	400	—	Good	Fair	Good	Good	—
—	285	330	8,000	—	—	—	10^{13}	500	—	Good	Fair	Good	Good	—
Nil	210	320	2,000	—	26	—	3×10^{17}	1,000	0.1	Good	Excellent	Swells	Swells	Swells
Nil	185	320	1,750	—	25	—	3×10^{17}	1,000	0.1	Good	Excellent	Poor	Poor	Poor
Nil	175	320	1,500	—	24	—	3×10^{17}	1,000	0.1	Good	Excellent	Poor	Poor	Poor
1.0	185	—	3,800	—	500	260	3×10^{14}	500	—	Fair	Fair	Fair	Fair	Fair
1.0	180	—	3,200	—	500	310	4×10^{14}	500	10	Fair	Fair	Fair	Fair	Fair
1.0	185	—	3,150	—	500	335	2×10^{13}	500	11	Fair	Fair	Fair	Fair	Fair
1.0	165	—	2,400	—	500	350	3×10^{10}	400	—	Fair	Fair	Fair	Fair	Fair
1.0	165	—	1,600	—	—	340	3×10^{9}	400	—	Fair	Fair	Fair	Fair	Fair
Below 1.0	180	—	7,100	—	500	0	1×10^{13}	400	—	Fair	Fair	Fair	Fair	Fair
Below 1.0	180	—	7,100	—	500	0	1×10^{13}	400	1.5	Fair	Fair	Fair	Fair	Fair
1.0	175	—	3,150	—	—	335	1×10^{13}	400	—	Fair	Fair	Fair	Fair	Fair
1.0	160	—	2,600	—	—	330	—	400	—	Fair	Fair	Fair	Fair	Fair
9.0	160	—	2,200	—	—	330	—	400	—	Fair	Fair	Fair	Fair	Fair
9.0	175	—	2,700	—	—	310	—	400	—	Fair	Fair	Fair	Fair	Fair
0.1–2.0	190–230	300	5,000–8,500	Good	—	1–5	10^{15}–10^{19}	500–700	0.002	Good	Good	Poor	Fair	Poor
0.1–1.0	169–232	—	3,500–6,900	—	0.8×10^{5} – 1.8×10^{5}	—	10^{10}–10^{12}	250–400	2.0–2.4	Poor	Poor	Fair	Excellent	Poor
0.1–1.9	169–232	—	4,100–6,900	—	1.85–0.95×10^{5}	—	10^{10}–10^{12}	250–400	2.0–2.4	Poor	Poor	Fair	Excellent	Poor
0.1–1.7	169–232	—	4,050–6,900	—	0.95–1.85×10^{5}	—	10^{10}–10^{12}	250–400	2.0–2.4	Poor	Poor	Fair	Excellent	Poor
—	260	—	57,000–61,000	—	18,400	—	10^{16}	—	—	—	—	—	—	—
—	30	350–400	600–1,000	0.8	—	250–650	—	350	0.1	Fair	Fair	Poor	Poor	Poor
—	30	350–400	600–1,000	2.6	—	250–700	—	400	0.4	Fair	Fair	Poor	Poor	Poor
—	30	350–400	600–900	1.7	—	150–700	—	400	0.1	Fair	Fair	Poor	Poor	Poor
—	30	350–400	550–800	1.4	—	140–250	—	400	0.4	Fair	Fair	Poor	Poor	Poor
—	150–250	—	5,800–6,700	—	4–5×10^{5}	1.5–1.8	Above 10^{13}	Above 400	0.0002–0.0004(b)	Fair	Excellent	Poor	Crazed	Poor
—	150–250	—	5,600–6,000	—	3.5–4.5×10^{5}	2.5–40	10^{14}	—	0.0001–0.0005	Fair	Excellent	Poor	Crazed	Poor
—	—	—	2,600	Excellent	—	280	—	—	—	V. good	V. good	Fair	Fair	Fair
—	—	—	2,000	Excellent	—	300	—	—	—	V. good	V. good	V. good	V. good	Fair
—	—	—	7,400	Excellent	—	18	—	—	—	Excellent	Excellent	Excellent	Excellent	Fair
—	—	—	3,000	Excellent	—	200	1×10^{14}	450	—	V. good	V. good	Fair	Fair	Fair
—	—	—	2,900	Excellent	—	270	1×10^{13}	440	—	V. good	V. good	Fair	Fair	Fair
—	—	—	2,000	Excellent	—	330	5×10^{10}	400	—	V. good	V. good	Fair	Fair	Fair

orption given percentage and not in terms of milligrams

APPLICATIONS OF EXTRUSIONS

A survey of the products of an important and growing branch of the plastics industry.

EVERY major industry now finds an important field of application for thermoplastics extrusions. In the following pages some of the uses to which extrusions have been put are recorded under the rough sub-divisions of tubes, cables, sheet and film, rigid and flexible sections. In the last-mentioned part uses have been classified according to different industries. Most of the extrusions described are in current production: some, however, are experimental, whilst others may merely be suggestions which have not yet been proved in practice. It is hoped that this survey may indicate the many actual and potential uses of this growing branch of the plastics industry.

GUIDE TO APPLICATION SECTION

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RIGID AND FLEXIBLE TUBES

IN dealing with applications of extruded plastics we have classified into the category of tubing those extrusions where piping or tubing is used for the conveyance of fluids.

One of the earliest outlets for plastics in this field was p.v.c. garden hose pipe which became very popular as a replacement for rubber, particularly because of light weight and good ageing properties. As with many other plastics productions in their early stages p.v.c. garden hose frequently became the victim of ignorant and sometimes even wilful mis-use of potentially good materials. Early extrusion compounds contained plasticizer which could not withstand low temperatures; fillers were incorporated to lower price thereby reducing strength of the hose to below actual requirements and extrusion techniques and temperature control were of the crudest type. Fortunately, increased knowledge of plasticizer, stabilizer and compounding and processing techniques soon improved so that manufacturers are now able to offer colourful p.v.c. garden hose that is not only lighter and more durable than rubber hose but which also competes economically in price.

By contrast to this chequered entry into the consumer markets, most other uses of plastics pipes have been pioneered in technical fields where extrusion of the properties of plastics have led to an evaluation of their advantages and their limitations. The quality which has led to the choice of plastics in most technical applications is inertness to the liquid or gas being conveyed. This means absence of toxicity where water, food or drink are being conveyed and chemical resistance where corrosive materials such as acids, alkalis or crude oil are carried.

The materials most favoured for these applications are cellulose acetate butyrate, polythene and polyvinyl chloride, the latter completely unplasticized and rigid.

Cellulose Acetate Butyrate

Due to the difficulty of obtaining cellulose acetate butyrate which is only produced in America practical experience has been gained only by the few in this country. In the U.S.A., however, the Tennessee Eastman Corporation (who are represented by Kodak, Ltd., in Great Britain) have pioneered much work with piping extruded from their cellulose acetate butyrate (Tenite II). The major market appears to be in the oil-producing industry where light weight, lowest installation costs and resistance to highly corrosive crude oil gives a life many times that of steel piping. In addition, the smooth finish of the pumping bore reduces energy requirements. A recent installation made use of nine miles of Tenite piping, three inches in diameter. Experimental Tenite pipe lines for conveying natural gas to consumers have also proved successful.

Polythene

In Great Britain work on extruded tubing has until recently concentrated largely on polythene. This material manufactured by I.C.I. is known for its inertness, being completely non-toxic and resistant to strong acid, alkalis and many organic solvents. It is used in the pure polymer form, no additives being required other than pigments if coloured extrusions are desired. Where tubing is likely to be exposed to daylight some 2-3% carbon black is added to prevent degradation by U/V light. The simple and pure composition of this material has helped considerably the introduction of standards for polythene tubes. The publication early this year of B.S. 1972:1953 "Polythene Tubes for Cold Water Services" and B.S. 1973:1953 "Polythene Tubing for General Purposes including Chemical and Food Industry" has enabled the introduction of such tubes, for housing, agriculture, and many industrial applications. In agriculture and some housing work additional attractive features of polythene pipe are the ease of laying by mechanical moleploughs and the longer length (coils up to 500 ft.) which can be laid without the necessity for jointing.

There are at present a number of manufacturers offering standard tubing; these include I.C.I. Plastics Division, Tenaplas, Ltd., The Telegraph Construction and Maintenance Co., Ltd., and Rediweld, Ltd. Extruded polythene pipe of larger dimensions up to 12 in. in diameter has also been used successfully in the chemical industry and for conveying water. A six inch bore tube produced by J. J. Wade (London), Ltd., was used successfully for pumping water away from flooded areas in eastern England at the beginning of this year. This pipe with wall thickness of $\frac{3}{32}$ in. is made in 16 ft. lengths. Its light weight makes it easy to assemble and transport and recent Civil Defence exercises showed that several miles can be laid in a very short time to supply water for fire-fighting in attacked areas.

Polyvinyl Chloride

The excellent chemical resistance of unplasticized polyvinyl chloride makes this material a strong rival for polythene. Rigid vinyl pipe was used extensively in Germany during World War II but has only recently been made in this country. The many applications will undoubtedly be in the chemical industry where the strength of the rigid p.v.c. can be combined with inertness. It is strong enough to support its weight and can be used in much the same way as metal pipe. Tensile strength quoted by one manufacturer is about 7,000 lb./sq. in., flexural strength 14,000 lb./sq. in., specific gravity 1.35 to 1.6. Maximum service temperature is from 160 to 170° F. to minimum of minus 70° F. Extruders currently offering rigid vinyl tubes up to 6-in. diameter are Melwood Thermoplastics, Ltd., Chemical Pipe and Vessel Co., Ltd., Erinoid, Ltd., Lacrinoid Products, Ltd., Rediweld, Ltd. British Moulded Plastics, Ltd., also extruded rigid p.v.c. pipes which are sold by Prodorite, Ltd.

A major functional use for rigid and partly plasticized p.v.c. is also in conduits for electrical conductors. One of these is the Gilflex conduit for which p.v.c. tubing is extruded by Erinoid, Ltd. Advantages of the conduit are that it is insulating, unaffected by damp and corrosive atmospheres and it is non-flammable. There are several types of conduit including one for the normal house installation and a tougher type for industrial installations.

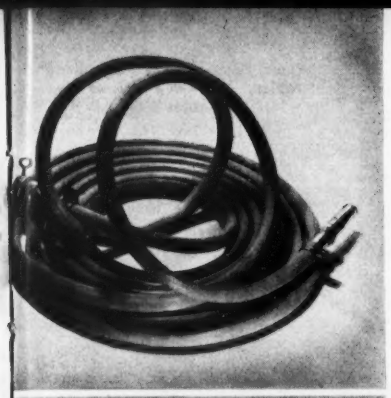
The latter is completely watertight and is available with a full range of accessories and lighting which may be installed in corrosive atmospheres. Conduits are self-threading into the screwed spouts of moulded fittings. The fact that p.v.c. is an insulating material of course makes it impossible to use such conduits for earthing purposes.

In housing, p.v.c. tubing has been used for flush pipes. Manufacturers of such pipes include Thomas De La Rue and Co., Ltd., and Hawkhead Bray and Co., Ltd.

To assist installation of plastics tubing, standard metal joints have usually been used so that metal and plastic pipes may be interchangeable.

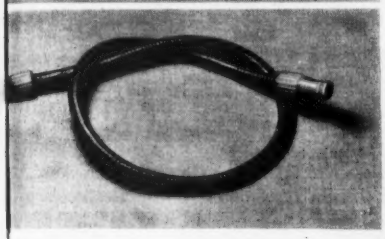
Moulded bends, tee pieces, valves, etc., are

(*Continued on page 429*)

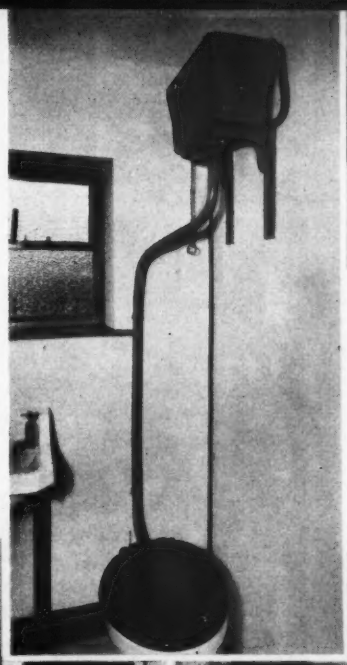


(Right) Cistern flush pipes have been extruded from polythene and rigid p.v.c. This illustration shows a polythene installation. (Photo I.C.I.)

(Left) P.v.c. garden hose. (Melwood Thermoplastics Ltd.)



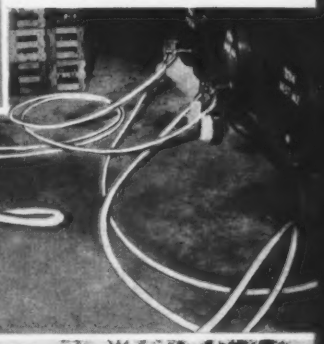
(Left) Wire-reinforced flexible p.v.c. gas tubing (Creators Ltd.)

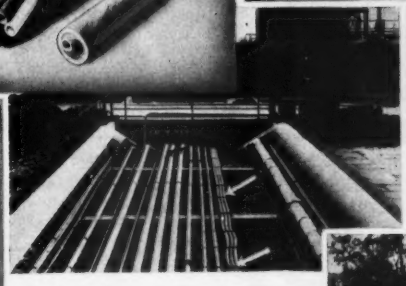


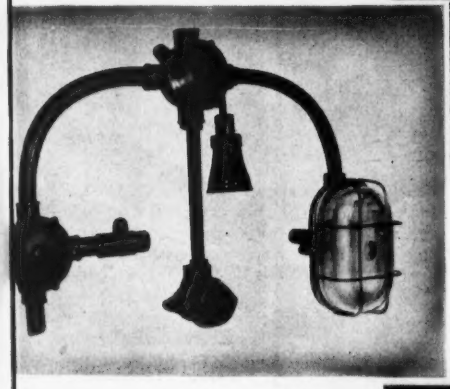
(Above) P.v.c. petrol pipe reinforced with cloth and cellulose acetate strip made by Melwood Thermoplastics Ltd., for Wilkinson Rubber Linatex Ltd.

(Below) Beer-pump installation, with polythene tubing by the Telegraph Construction & Maintenance Co. Ltd.

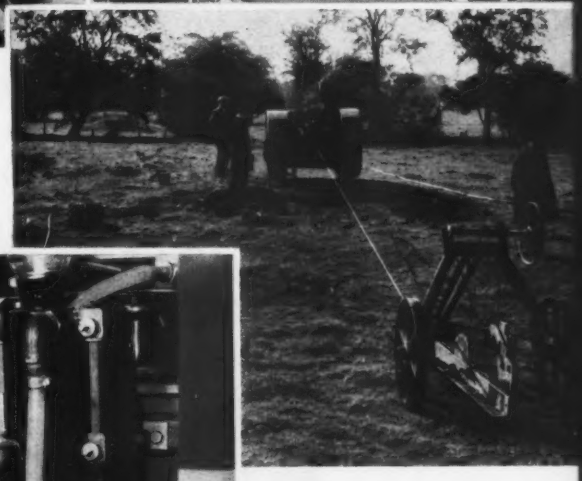
(Below) Flexible p.v.c. conduit for electrical wiring system is extruded by Erinoid Ltd., for Gilflex Conduits, Ltd.



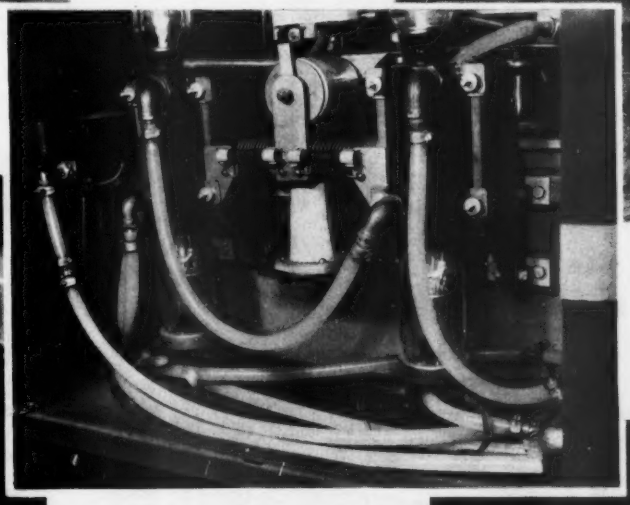


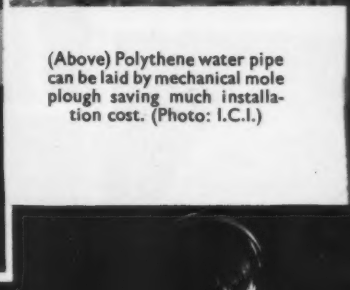


(Above) "Pigemultiflo" multiway p.v.c. tubes (see inset) covered with p.v.c. sheathing, installed in chemical plant.



(Below) 12-in. bore polythene pipe extruded by Tenaplas, Ltd., being packed for transport. These pipes are employed mainly in chemical plant.





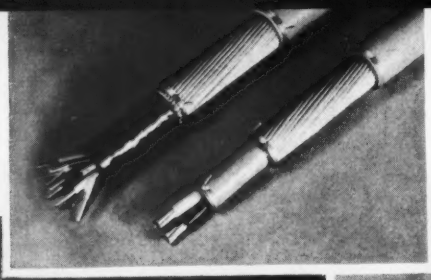
(Above) Polythene water pipe can be laid by mechanical mole plough saving much installation cost. (Photo: I.C.I.)

(Above) Polythene tubing finds many industrial applications as in the water-cooling tubes for a high frequency generator. (Rediweld Ltd.)

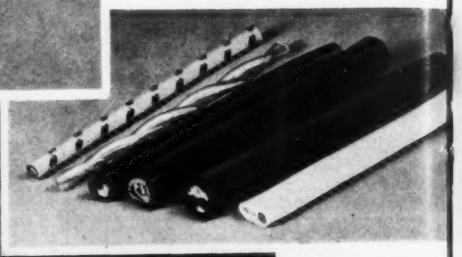
(Right) British Oxygen Co., Ltd.'s Argonarc welding equipment employs p.v.c. tubes both for conveying Argon gas and cooling water to the welding torch.

(Right) Range of Vybak p.v.c.-sheathed cables. Photograph : Bakelite Ltd.

(Left) P.v.c.-sheathed and -insulated cables, by Associated Technical Manufacturers Ltd.

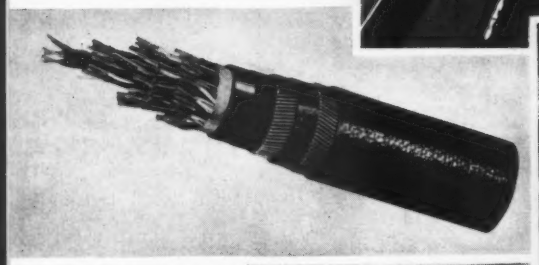


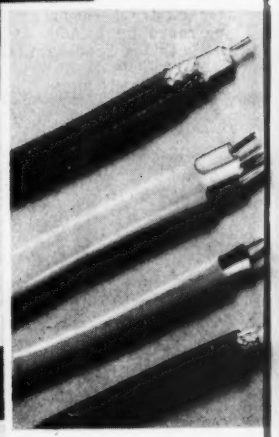
(Left) P.v.c.-sheathed armoured cables, by Rist's Wires and Cables Ltd.



(Above) Specimen of cables made by Rist's Wires and Cables Ltd.

(Below) P.v.c. cables and polythene air-space cables.

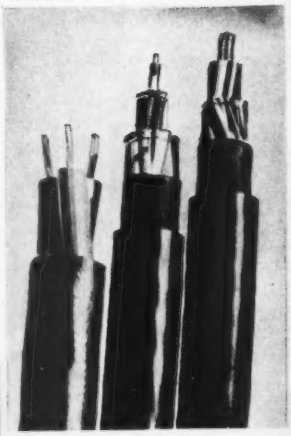




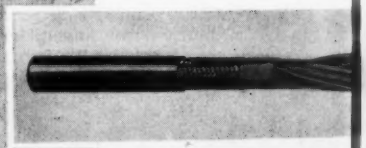
(Above) Multi-cored armoured cable made by British Insulated Callender's Cables Ltd., with extruded p.v.c. insulation and sleeving.

(Right) Examples of p.v.c.-sheathed cables made by Enfield Cables Ltd.

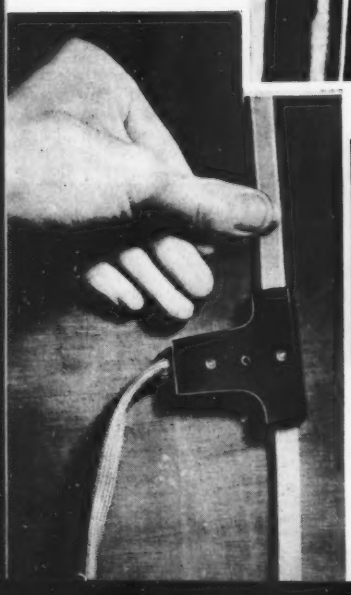
(Below) Flexible extruded dipole aerial, manufactured by E.M.I. Sales and Service Ltd.

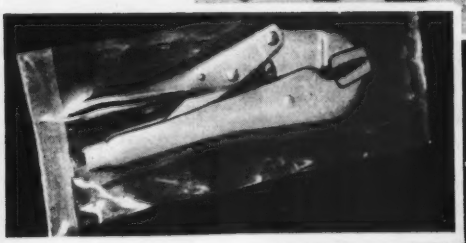


(Below) Television camera cable with polythene insulation and an outer sheath of p.v.c. By British Insulated Callender's Cables Ltd.



(Left) Extruded cellulose sheet, manufactured by British Cellophane Ltd. and applied to packaging.





(Above) Extruded polythene film used to package pliers. Manufactured by Porosan Ltd.

(Right) P.v.c. is used here to give attractive liquid packs, by Technopol Laboratories Ltd.

APPLICATIONS OF EXTRUSIONS

(*Continued from page 426*)

also available both in polythene and p.v.c.

The preparation of Standards for rigid p.v.c. tubing is now under way but, due to the many materials manufacturers concerned and the great variety of polymers and other ingredients which can be employed, publication may be delayed for some time.

Plasticized polyvinyl chloride has also been used for other purposes than garden hose mentioned earlier, non-toxic grades have been used for beer piping and tubes reinforced either by metal spirals or by a combination of cloth and cellulose acetate ribbing have been employed in cars and aircraft as flexible petrol tubing. The slight leaching effects which petrol has for p.v.c. plasticizers does not appear to affect the performance although embrittlement may occur if the tubing is dried excessively. Wire reinforced plastics pipes are manufactured by Bardex Engineering Co., Ltd., and Creators, Ltd., and the acetate reinforced tubing is produced for Wilkinson Rubber Linatex, Ltd., by Melwood Thermoplastics, Ltd.

An interesting installation of p.v.c. tubes is the multi-way "Pigemultiflo" tube assembly made by Pirelli-General Cable Works, Ltd., and described in *Plastics*, May, 1952. Such assemblies are available with seven ¼-in. tubes or 14 ⅛-in. tubes laid in single assembly with an overall p.v.c. sheath. Different colours can be employed to identify the tubes. The first commercial installation was put into service in 1946 in connection with an extensive instrumentation system at a chemical works. Accurate sea-water level indication was obtained by measuring the change of air pressure in the tubes due to the change in water level.

WIRES AND CABLES

THE entry of plastics materials into the cable-making industry is now a recognized fact and by the introduction of various British Standards Specifications plastics have been recognized as important cable-covering materials and indeed, in many instances, offer advantages over natural rubber.

Polyvinyl Chloride

It will be recognized of course, that the use of plastics by the cable industry greatly simplifies cable production. The considerable quantity of expensive machinery that is called for in the milling and compounding to natural rubber is unnecessary in the case, for example, of p.v.c. The cable industry, being one of the largest customers for both plastics extrusion materials and equipment, therefore offers a unique opportunity for a study of the extrusion technique.

In its simplest form, the covering of wire by p.v.c. is an extremely economic and speedy process. Coatings up to 0.003 in. thick can be effected at high speeds, outputs being achieved of up to 7,000 yards per hour. The machinery that is called upon here consists essentially of efficient take-off equipment and examples of such equipment will be found on page 417. Wire covered by this technique finds wide application in household circuits, the automobile industry and telecommunications. The fact that the p.v.c. compound can be diversely coloured enables plastics materials to fit in with standard wiring identification schemes. In this field the properties called for are principally, good insulation, good resistance to reasonable wear and good ageing properties. On all of these counts p.v.c. materials supply an adequate answer.

We believe that earliest work in this field started in 1932 when Suflex, Ltd., commenced extruding the German p.v.c. which had the trade mark Mipolam. Rist's Wires and Cables, Ltd., were also amongst the first to use Mipolam. The quantity extruded was small until the outbreak of war when the company succeeded in obtaining Ministry of Supply sanction to the covering of telephone communication cables by p.v.c. A more recent revelopment by Rists has been the use of p.v.c. in the construction of wiring harnesses for automobiles First commenced some seven years ago the experiment has been found to be highly successful, particularly because of the oil and petrol resisting properties of certain grades of p.v.c.

The same type of wire, of essentially simple construction, is employed by Rists in the manufacture of house wiring and factory installations. In this latter case, corrosive fumes such as sulphur which would attack rubber insulated cables leave the p.v.c. unharmed.

Similar techniques are employed by Wandleside Cable Works, Ltd., utilizing both British and American extrusion equipment. This company has two American Royle installations (referred to on page 414), both of them complete with highly efficient take-off apparatus, and capable of very high rates of production. As an adjunct to this apparatus the company has installed very ingenious spark-testing equipment which operates on a continuous basis. Reels of p.v.c.-coated wire are fed through the inspection machinery at high speeds and faults are recorded automatically. The Wandleside technique offers a continuous throughput from the bare cable to the coated and inspected finished product.

J. Day and Co., Ltd., have recorded the upheaval which was consequent upon the introduction of p.v.c. into the cable-making industry and have drawn particular attention to the advantages of wide colour ranges. The fact that over 25 different and distinctive shades of colour can be obtained with p.v.c. simplifies greatly the work of installation engineers and maintenance staff.

It is not surprising that a material which is flexible at temperatures as low as minus 40° C., is resistant to abrasion, oils, acids and alkalis and has low water absorption should find such wide application in this field. It is due to this unique feature that J. Day have been able to effect contracts for p.v.c.-covered wire with such government departments as the Ministry of Supply, the G.P.O., and the Admiralty.

We come now to the more complex cable structures, where p.v.c. is used not merely as a coating for the conductor wires but also as a composite sheathing for a number of such coated wires. Such structures are frequently armoured and superimposed again with a final sheathing of p.v.c. to give a very tough cable. The illustrations show clearly the build-up technique that is required. Here again the use of plastics considerably simplifies methods of manufacture. Using rubber or paper as an insulant, braiding is necessary to provide a sheathing against wear. Following traditional techniques therefore the manufacture of such a cable is a lengthy and costly business. By straightforward extrusion of p.v.c. the process is immediately reduced to one of mass production principles, and outputs are greatly increased. Typical applications of armoured cable may include machine tool wire, power switchboard wiring, and telephone cables. In general, therefore, it can be said that p.v.c. is used extensively for the insulation and/or covering of telephone cables, instrument connecting wires and for cables, wires and flexibles in general low-voltage work. This is particularly true where its oil and fire resistance properties are useful. The availability of the material in a wide range of colours greatly simplifies circuit identification particularly in the case of complex multi-core cables.

Polythene

Polythene has established a place for itself by virtue of its outstanding electrical properties in the cable field, particularly in the insulation of radio-frequency telecommunications cables, where its low loss and low capacitance characteristics make it particularly suitable.

Although polythene is mainly used at the moment for insulating cores in multi-core cables sheathed in p.v.c., the applications are growing and it is anticipated that there will be big developments in this field in the next few years. For example, in the mains cable field, considerable ranges of low-voltage underground surface cable with polythene insulation and wire armoured have been installed. These cables are not sheathed with lead, so that, in variance with lead-sheathed, paper-insulated cables there is a desirable saving in weight. In addition, insulation is simplified because indoor telecommunications can be made without the special sealing properties required by paper-insulated cables. Considerable ingenuity has been exercised both by the electrical engineer and the extruder in the design of efficient h.f. conductors, using techniques such as co-axial cables and air-spacing to improve insulation and prevent interference between different messages. Some of the most complex forms have been in under-sea and trans-continental cables, manufactured by The Telegraph Construction and Maintenance Co., Ltd. Submarine cables, formerly the preserve of gutta-percha are now insulated with polythene, giving a higher working speed and resistance to distortion and permitting the repeater stations to be spaced at greater distances apart. The illustrations show examples of air-spaced cables of the co-axial type, lightly armoured and p.v.c. sheathed. British Insulated Callender's Cables, Ltd., have conducted considerable research into the use of polythene and have

published valuable information. J. Day also make use of this material in the manufacture of cables for radar, television, aircraft and high frequency.

Polytetrafluorethylene

British Insulated Callender's Cables have carried out considerable work in the use of p.t.f.e. in the cable-making industry. Supplied as a white granular powder it can be used as a wire covering by means of a modified enamelling technique but more frequently as an extrusion.

The material has good electrical properties, similar to those of polythene, coupled with the important advantage of being able to withstand an extremely wide temperature range. It is attractive as the dielectric of wires and flexibles for specialized applications where its high cost can be justified. It has, for instance, been found particularly useful for communication, auxiliary and ignition wiring which must pass through the high-temperature zones of jet aircraft. However, its development as a cable insulation is still at an early stage.

Nylon

This material is in the early stages of development for cables and its applications so far are mainly of a specialized nature where its inherent properties can offer specific advantages. For example, in the form of a thin film sheath extruded over conventional insulation it provides a high degree of abrasion resistance which has been employed successfully for military field telephone cables which must withstand the wear of being dragged through rough country. Again, as a covering for aircraft cables it provides a useful degree of protection against a synthetic lubricating oil being used in jet engines.

Conclusion

Plastics materials can offer many valuable properties to the cable-maker and, in addition, can simplify considerably the actual operations involved in cable manufacture. It is, however, a fact that the majority of cables are subject to severe and rigid specifications fixed by the various Government Departments, the British Standards Institution, and the British Engineering Standards Association. By virtue of the high cost of cable manufacture and because of their intrinsic importance, every care must be taken by the companies and authorities concerned to ensure that these materials are exploited in a satisfactory manner. We can, therefore, look forward to further intensive research in the properties of the various plastics available and to an increasing use by the cable manufacturers of these materials.

SHEET AND FILM

Packaging is recognized today as one of the most important partners in industrial progress, and it is very largely due to the plastics industry that such great progress has been made in recent years. An outstanding example of this comprises manufacture of "lay-flat" tubing. By extruding thin tubes of, for example, polythene, a basis for an ingenious pack is manufactured. Through lack of rigidity, by virtue of its thinness, such tubing automatically collapses. Articles for packing which may range from peanuts to industrial components can be inserted, and an effective closure can be formed by heat-sealing across the tube at desirable distances. A number of companies have successfully exploited this form of packaging which offers substantial advantages. Polythene as a material is not water-absorbent for normal purposes. In addition it is highly resistant to chemical attack and remains flexible and tough at temperatures below —60° C. In this direction the packaging of frozen foods which tend to lose water rapidly unless prevented, is immediately suggested. Polythene is highly tear-resistant, can now be printed upon, can be stuck together by means of certain adhesives and, being thermoplastic, can be heat-sealed.

Running parallel with the development of polythene as a packaging medium has been the introduction of a number of heat-sealing machines and machines for printing on to polythene. One of the companies which has led development in this field is Porosan, Ltd., producing both sealing machines and the actual film with a trade mark Porothene.

Alkathene film, manufactured by Imperial Chemical Industries, Ltd., is available in both tubular and sheet form. Possessing again the basic important properties of polythene, the tubular form is available in wall thicknesses from 150 gauge to 500 gauge in any "lay-flat" width up to 36 in.; 120 gauge is also available in widths up to 10 in. The sheet film is wound on reels in gauges ranging from 150 to 1,000 and in widths from ½ in. to 50 in. Special non-standard thicknesses can be manufactured by arrangement. Applications for these products include drum liners, where their chemical inertness, toughness and water vapour impermeability make them ideal for packaging corrosive and hygroscopic chemicals.

The food industry makes considerable use of Alkathene film, ranging from cooking fats to frozen liquid eggs. On grounds of sales appeal the material has the important advantage to offer in that the customer can examine the quality of the product prior to purchase. Similarly, in pharmaceutics, in the packaging of electrical components and machine parts, in the protection of machinery itself, Alkathene is used.

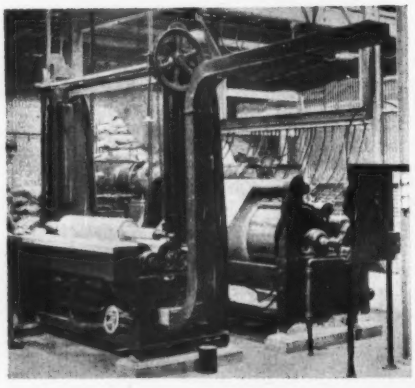
Besides I.C.I., who manufacture polythene both in the raw material state and in finished film, a number of other converters are extruding tubular and flat film for packaging purposes. Amongst these are Transparent Paper, Ltd., who produce Diothene.

Another interesting development in the packaging field has been the laminating of polythene to paper and more recently also to metal foil, cork and other materials, to provide chemically resistant wrapping and lining materials. Producers of paper coated with polythene by this method are The Telegraph Construction and Maintenance Co., Ltd., Chilton Paper Products, Ltd., and Clyde Paper Co., Ltd., whilst other paper converters are actively investigating the same subject. With the improvement in plasticized p.v.c. compositions it is now possible to extrude film both in flat and tubular form down to thicknesses formerly only obtainable by calendering. This material is not only less costly but for some applications has better chemical properties than polythene, and it can of course be welded by the h.f. method. The method of making liquid containers by continuously filling p.v.c. tube and sealing at intervals has been successfully exploited by Technopol Laboratories, Ltd.

P.v.c. sheeting has also been extruded in thicker gauges and, combined with embossing rollers incorporated in the take-off equipment, sheeting suitable for bag making, upholstery, etc., has been produced. This technique was demonstrated by R. H. Windsor, Ltd., at the 1951 British Plastics Exhibition and this company's equipment is used commercially by at least one manufacturer in the U.S.A. for the same purpose.

B.X. Plastics have long been prominent in the extrusion of cellulose acetate for packaging and other purposes. This material, possessing a high level of optical clarity, is extremely useful in the fabrication of attractive display units.

Other materials which have been extruded in film form include cellulose, cellulose acetate butyrate, polystyrene, which has outstanding electrical properties and is used for condensers, etc., and recently Terylene polyester with properties that suggest interesting uses in the electrical and other industries.



Part of the new plant laid down by Chiltern Paper Products, Ltd., for the large-scale production of the new polythene-coated paper and board materials. By this process the polythene film is extruded directly on to the backing material, thus providing for highly efficient production means and excellent bonding properties. (Photo by courtesy Frank W. Egan and Co., New Jersey, reproduced from "Packaging.")

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BATTERY BOXES

HIGH IMPACT *Grade H.I Natural*
Impact strength above General Purpose grade = 400%

MEDIUM IMPACT *Grade M.H.I Natural*
Impact strength above General Purpose grade = 100%

HIGH MOLECULAR WEIGHT *Grade 2.C.L Crystal Clear*
Impact strength above General Purpose grade = 50%

- ERINOID grades of polystyrene have been accepted by the Ministry of Supply for aircraft battery manufacture.
- The toughness of all three grades makes them ideally suitable for battery box manufacture.
- ERINOID polystyrene is considerably lighter in weight than conventional battery box materials.
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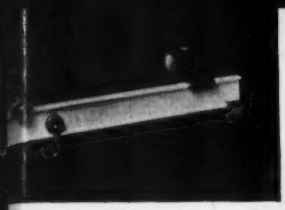
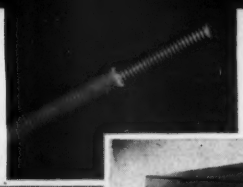
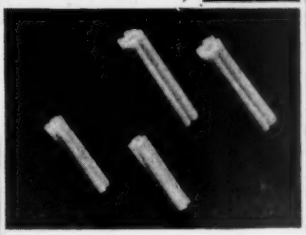


(Right) P.v.c.-sheathed expanding curtain wire.



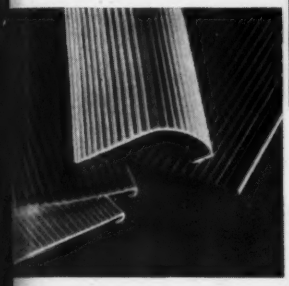
(Right) Panel-edging and corner sections in rigid p.v.c. (Melwood Thermoplastics, Ltd.)

ove) Rufflette curtain rail in p.v.c., by Thomas French and Sons, Ltd.

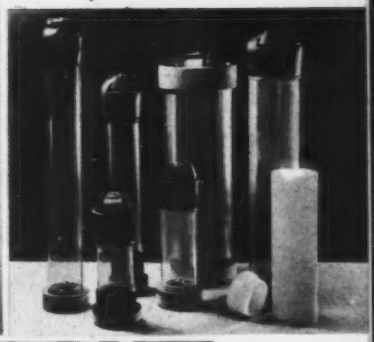


(Above) Hewitt wall plugs.

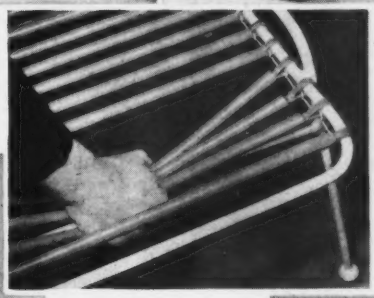
(Below) Carriers made from acetate tube for Lamson pneumatic tube system (BX Plastics, Ltd.)



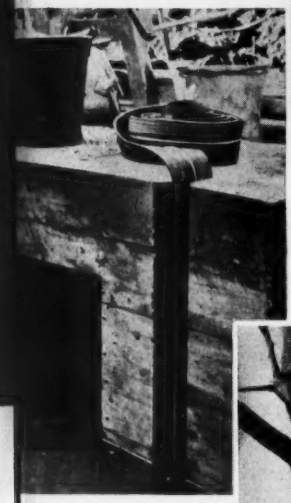
bove) High-impact polystyrene rips for refrigerator breaker mes. (Thos. De La Rue and Co., Ltd.)



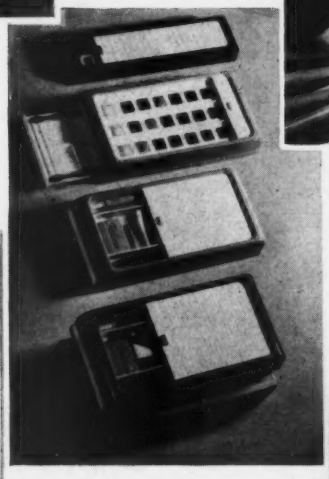
(Above) Cabinet, with rigid p.v.c. roller shutter slats. (Thos. De La Rue and Co., Ltd.)



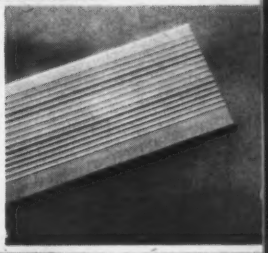
(Left) P.v.c. sleeving covers the springs of chair by Ernest Race, Ltd. (BX Plastics, Ltd.)



(Above) Murphy BU183 portable radio, trimmed with flexible p.v.c. edging. (Melwood Thermoplastics, Ltd.)

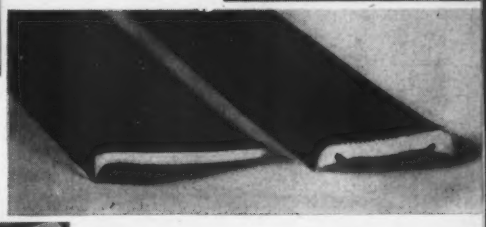


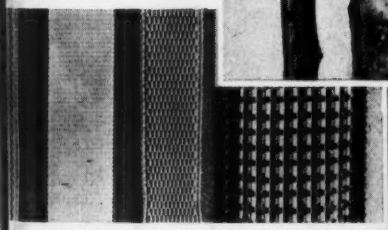
(Right) Kelvinator refrigerator breaker strip in high-impact polystyrene. (Ashdowns, Ltd.)



(Above) Durajoint waterproof expansion joint. (Duratube and Wire, Ltd.)

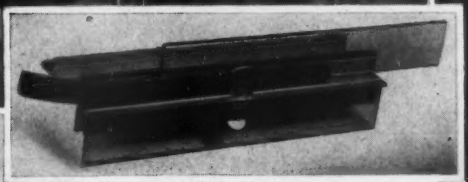
(Above) Boxes with cellulose acetate butyrate roller shutter strips. (Rolinx, Ltd.)
(Left) Flexible p.v.c. tree tie. (S. H. Rainbow.)

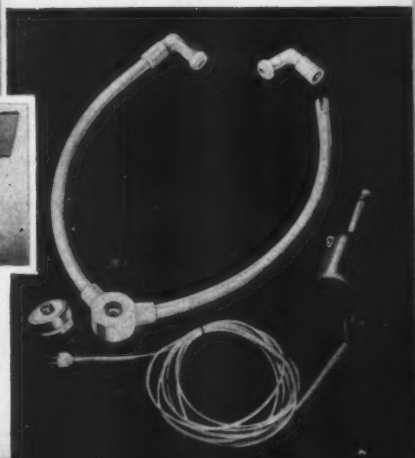


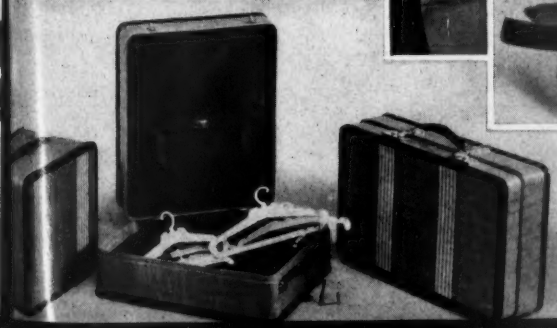


(Above) Tapes woven from p.v.c. filament. (Clutsom and Kemp, Ltd.)

(Above) Floor coving and stair-tread in filled p.v.c. (Thos. De La Rue and Co., Ltd.)



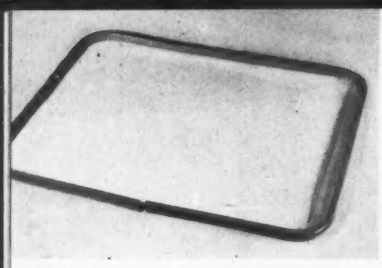


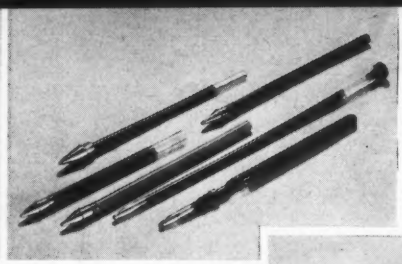


(Above) P.v.c. glazing channel for aluminium greenhouses. (V. and N. Hartley, Ltd.)

(Left) Abrasion-resistant p.v.c. edging for Rev-Robe cases made by W. Wood and Sons, Ltd.

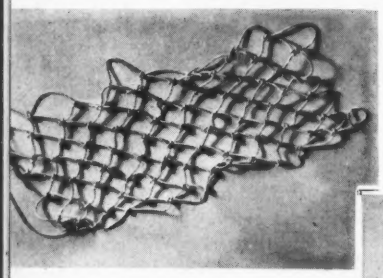
(Right) Emidicta stethophones. (E.M.I. Sales and Service, Ltd.)



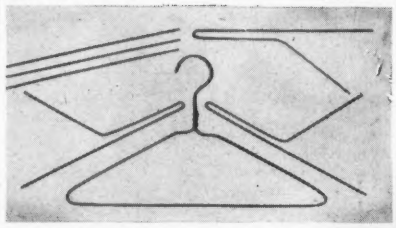


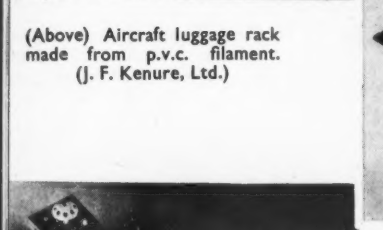
(Left) Ball-point pen tubes in cellulose acetate and polythene. (Thos. De La Rue and Co., Ltd.)

(Above) Cronapress continuo bell push employs p.v.c. se tion. (C. and C. Marshall, Ltd (Below) Toothbrush containe made from cellulose aceta tube. (Thos. De La Rue a Co., Ltd.)

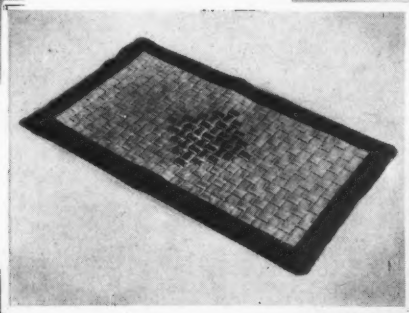


(Above, left) TV screen surround in rigid p.v.c. (Melwood Thermoplastics, Ltd.)

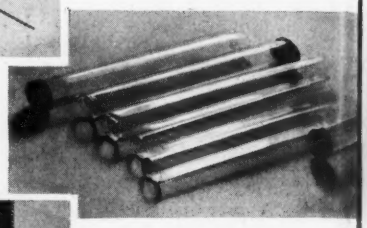


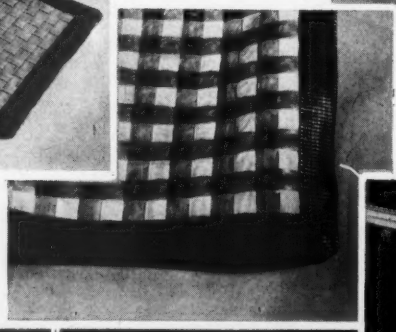


(Above) Aircraft luggage rack made from p.v.c. filament. (J. F. Kenure, Ltd.)



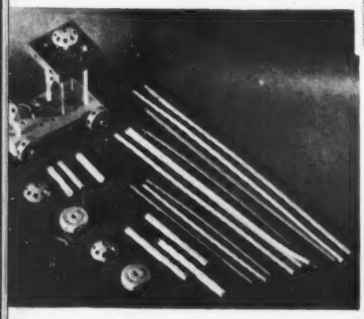
(Above) P.v.c.-coated wire is made into coat-hangers, racks, etc. (Creators, Ltd.)



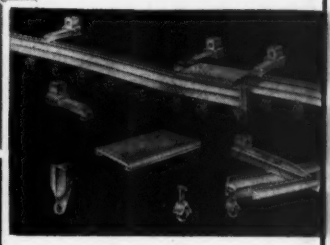


(Below) 'Swish' rigid p.v curtain rail and fittings (Cove try Motor and Sundries C Ltd.)

(Above and right) Mats woven from embossed p.v.c. strip. (Platex.)

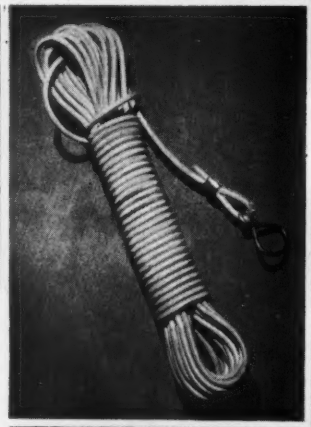


(Above) Small coloured tubes for toy set. (E.V.B. Plastics, Ltd.)

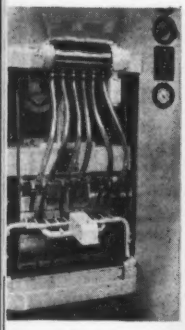


(Above) Cellulose acetate strip for basket trim.

(Below) Avery scale with gasket (right) extruded from Vybak p.v.c. by Plasticable, Ltd. (Photo : Bakelite, Ltd.)

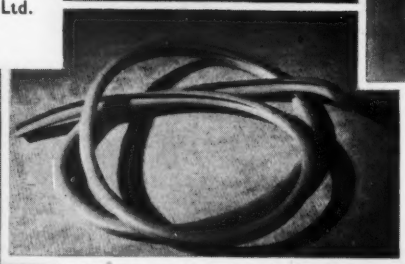


(Left) P.v.c.-covered clothes line. (Litchfield Bros., Ltd.)



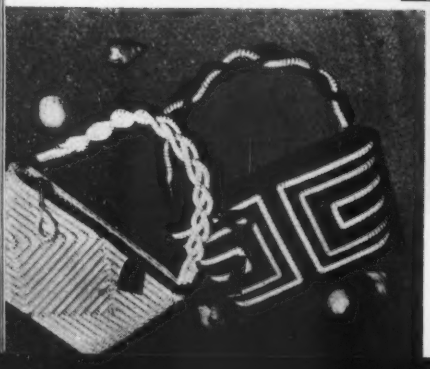
bove) Powder feed pes for Foster, Yates id Thom plastics moulding press.

(Above) Display models are blown from extruded acetate tube.



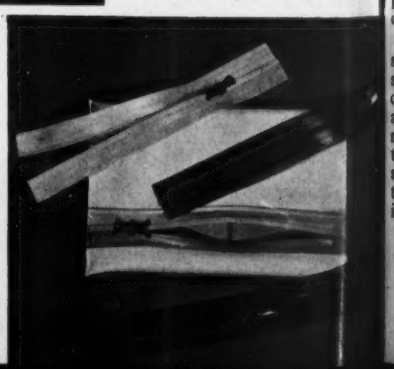
(Above) Miscellaneous flexi p.v.c. sections, including w piping and slide fastener. and C. Marshall, Ltd.)

(Below) Welded p.v.c. pur employ Flexigrip extruded sl fastener. (Flexigrip Co., Ltd



(Left) Cellulose acetate strip is made into bags.

(Right) Covered wire for gramophone rack.



Rigid and Flexible Sections

Some notes and sketches of new and established applications of plastics extrusions in different industries. The numbers in parentheses refer to the sketches on the following pages

Electrical

THE principal use of plastics extrusions in the electrical industry, that is polythene, p.v.c. and p.t.f.e., for the insulation of cables, and p.v.c. nylon for protective cable sheathing, has been dealt with earlier (page 429). The most advanced forms of cable are probably the polythene insulated semi-air-spaced cables, such as the star-shaped type (2) made by several leading cable-makers, or the special design of Transradio, Ltd. (1). Twin-feeds, spaced parallel wires (3) insulated with polythene are used in radio and T.V. work, one example being the flexible indoor T.V. aerial made by E.M.I. Sales and Service, Ltd. Thin-wall flexible p.v.c. sleevings serve in electrical wiring assemblies and thicker types of tubing are used as wiring conduit. To join groups or "looms" of cables, Hellerman Electric, Ltd., produce a slotted cable strap (5) fastened by means of injection-moulded p.v.c. studs. This company also makes sleeves with tabs for identification of terminals. British Railways use hot-stamped cellulose acetate sleeves for the same purpose. Ever-Ready now employ plastics sleeving to contain some of their dry-cell batteries. Extruded polythene film is approved by the Services for packing moisture-sensitive electrical instruments and components (4). Styrene foil and, more recently, Terylene film, is employed in condensers and other equipment requiring thin membrane insulation. A special type of ram extrusion process is employed by Pritchett and Gold and E.P.S., Ltd., in the manufacture of Porvic microporous unplasticized p.v.c. sheet for battery separators.

In the manufacture of radio sets, p.v.c. beadings and edgings strips facilitate assembly and provide both decoration and resistance to abrasion or wear. An example is the recent Murphy portable which has edging by Melwood. For portables, too, are the ribbed handle straps (6). In T.V. sets, rigid p.v.c. channelling has been used as a screen surround frame.

Building

Water pipes of polythene and unplasticized p.v.c. are probably the largest actual and potential application of plastics extrusions in the building industry. They are used successfully for cold-water supply, cistern downpipes, drainage and similar installations. Their advantages of light weight, resistance to corrosion and to frost make them specially suitable for prefabricated buildings exported to countries with extreme climatic conditions. Extensive trials have been carried out on a housing estate in Coventry and standards are already in existence for polythene tubing and in preparation for p.v.c. tubing. More details of this application are given on page 426.

A recent development in building construction is the use of flexible p.v.c. extrusions as waterproof expansion joints for concrete. Durajoint (19), for which Duratube and Wire, Ltd., have patents pending, is made in 3¼-in., 6-in. and 9-in. widths, to take varying water pressures in dams, swimming pools, tunnels and other situations where a completely water-tight joint is essential under different conditions. P.v.c. is claimed to be a great improvement on the bituminous materials, rubber or copper strip previously used. Erinoid, Ltd., who introduced a waterstop joint in March, 1952, say that it has since become firmly established in this field. A great advantage of the plastics extrusion is that it can be simply jointed by heat welding on site, using a soldering iron or similar tools.

In the U.S.A., Anchor Plastics have extruded split polythene tubing for use in pre-stressed concrete construction by a patented method.

I.C.I. recommend the use of polythene film as an acid-resisting, damp-resisting sub-floor for chemical factories where penetration of acids through flooring cracks may cause damage to the foundations. For the ordinary damp course in housing, polythene appears to offer no particular advantage over conventional treated paper.

Expansion joints for terrazzo flooring extruded from rigid p.v.c. are also replacing metal strips previously used. Melwood Thermoplastics, Ltd., have made a variety of sections for this purpose, one of which is shown (7). The choice of bright colours and the ease of forming to give intricate designs are valuable for the architect. In America, Anchor Plastics Co. Inc. have produced terrazzo strip from cellulose acetate butyrate, containing luminescent pigments, giving a floor with a design glowing for several hours after dark.

With a wide variety of flooring it is desirable to have a curved coving section where the floor meets the wall (18), and these have been made in mineral-filled p.v.c. by a number of companies, including De La Rue and Melwood. The latter are producing both a coving section and a stair nosing section for Hornflowa, Ltd., in connection with their p.v.c. floor tiles.

A satisfactory and economical alternative to glazier's putty has long been the search of the building industry and experiments naturally turned to flexible p.v.c. channels. It is, of course, essential to have a material that will retain flexibility and firmness over a wide temperature range, and a careful selection of plasticizers is therefore essential. The only commercial application of plastics glazing channel published in Great Britain is that extruded by V. and N. Hartley, Ltd., for use in their greenhouses. This company has devised a method of securing the glass in the plastics channel, which fits into the extruded aluminium frame by a special clip (8).

In the construction of wall panels partitions, etc., from decorative laminates of the Warerite and Formica type, or other kinds of sheeting, the joints between adjacent panels can be made using a variety of metal or plastics channel strips. Rigid p.v.c. has been used by Melwoods for different corner pieces (internal and external) (9, 10, 11, 12). If it is desirable to hide the screws fixing the panel edging to the wall or base material, it is possible to use Melwood's method, having a flexible cover strip running in a channel of the edging strip (13). Coloured cover strips are also used in combination with extruded aluminium edgings.

Plastics extrusions have been used as wall plugs for retaining screws in plaster, brickwork, stone, etc. These include the Hewitt wall plug (14) (*Plastics*, April, 1949, p. 214) and the Rynplug (15), made by John M. Perkins, Ltd. A longitudinal split ensures easy expansion from pressure of the screw.

Corrugated roof lighting made from cast acrylic sheet has become popular all over the world, and many schools, factories, etc., are today fitted with I.C.I.'s corrugated Perspex roof lights. In the U.S.A., production has now started on the manufacture of such corrugated sheeting by extruding acrylic material through a shaped die of 45-in.-developed width (16) (*Modern Plastics*, November, 1953, p. 108, gives a description of the process.)

Drainpipes and gutters for external use have been widely discussed and made experimentally, but there is no commercial production to date. Rigid vinyls, if suitably stabilized, would appear to offer advantages in lightness, durability and freedom from painting or other maintenance costs. Until such questions as maximum distance between supports and behaviour in strong sunlight and frost have been thoroughly tested this must remain a "pipe dream."

In restaurants, public buildings, etc., stair rails, supporting posts and similar tubular-steel structures can be given an attractive and durable finish by covering with a plastics extrusion. This can be done by softening cellulose acetate tube in a solvent, sliding it over the metal tube to be covered and allowing the solvent to evaporate so that a tight fit is obtained on contraction. Alternatively, the method of spirally winding a ribbed cellulose acetate strip (50) can be employed. Both methods are used by Dover, Ltd., whilst Roanoid Plastics, Ltd., extrude cellulose acetate directly over metal tubes, using a hydraulic ram extruder. P.v.c. shrink-sleeving for the same purpose is extruded by Lacrinoid Products, Ltd., under the name Vietum. This is supplied oversize and is shrunk on by heating. P.v.c. sleeving made by BX Plastics, Ltd., has been applied to rope (17), and a recent installation by J. Lyons and Co., Ltd., makes use of this colourful, washable rope to separate off parts of a restaurant.

All-plastic stair nosings have already been described. Another combination of plastics and aluminium extrusions is the Don stair tread, made by Small and Parkes, Ltd., which uses coloured p.v.c. treads in an aluminium stair nosing (20) to improve appearance and increase grip.

For electrical wiring in houses, factories, etc., plastics-insulated and sheathed leads are replacing rubber-insulated lead-sheathed wires, and iron and copper conduits are being ousted by rigid and pliable p.v.c. tubes.

Furnishing and Domestic Applications

Some of the uses of plastics in the home have been included in the previous section dealing with building. Coming to the interior fittings, we find such items as curtain rails, towel rollers, picture rails, etc. Many of these items have been extruded in Rockite (made by British Resin Products, Ltd.) phenolic material, including the box-section curtain rail shown (21).

This material never ousted the brass and aluminium rails, but during the metal shortage arising after the beginning of the Korean war, leading curtain-rail manufacturers, including Thomas French and Sons, Ltd., makers of the Rufflette curtain rails, introduced rigid p.v.c. rails. Difficulties were, however, experienced in service, mainly due to the need for more frequent supporting brackets, and when metals became more freely available this product was discontinued. An interesting system of this type was the Swish rail shown at the

1951 B.I.F. The sections—a curtain rail (23), a link bracket (22) and a valance rail—were extruded by Coventry Motor and Sundries Co., Ltd. Flexible p.v.c. in many colours is extruded over the expanding-wire type of curtain runner by L. N. Mills, Ltd., and Bardex Engineering Co., Ltd., giving a non-rusting, washable product (24). P.v.c. is also extruded by Creators, Ltd., over thick steel wire, which can subsequently be formed into such articles as coat-hangers, tie racks, gramophone record holders, flowerpot stands. Clothes lines covered with p.v.c. cannot rot and are easily cleaned, merely by wiping.

In furniture construction, extruded panel edging has been used in similar fashion to that described for buildings. Plastics edging strips (25) are particularly useful for desks, trays and kitchen furniture. For kitchen cupboards, De La Rue have developed a roller shutter consisting of interlocking rigid p.v.c. strips (26) of the same type as that used in the Kolinx pencil boxes. Furniture handles are cut from rod and sections of casein, cellulose acetate and phenolics.

Tubular steel furniture can be protected from wear and corrosion by plastics shrunk-on sleevings, in the same way as the stair rails, already described. Flexible p.v.c. sleeving is used to protect upholstery springs, an ingenious example being the chair designed for the Festival of Britain by Ernest Race, Ltd., using coloured sleeving made by BX Plastics, Ltd. With the increasing use of plastics sheeting for upholstery, flexible beadings and pipings are employed to make the seams attractive. For cane furniture cellulose acetate strip can be used to give coloured decorative effects, whilst in France chair seats and similar furniture have been woven from extruded nylon strip, giving greater strength and durability, and wider colour range than rattan cane. Finally, on the borderline between plastics and textiles, is Tygan. This cloth is woven by Fothergill and Harvey, Ltd., from polyvinylidene chloride monofilament extruded by BX Plastics, and is used in upholstery, wall-panelling, fly-screens, where hard wear and easy cleaning are essential.

Venetian blind slats appear to invite extruded plastics but, so far, there has been some difficulty in obtaining a material which will not sag or deform under exposure to strong sunlight in the thin sections required. Plastics extrusions are, however, being used successfully in the "ladders" for blinds.

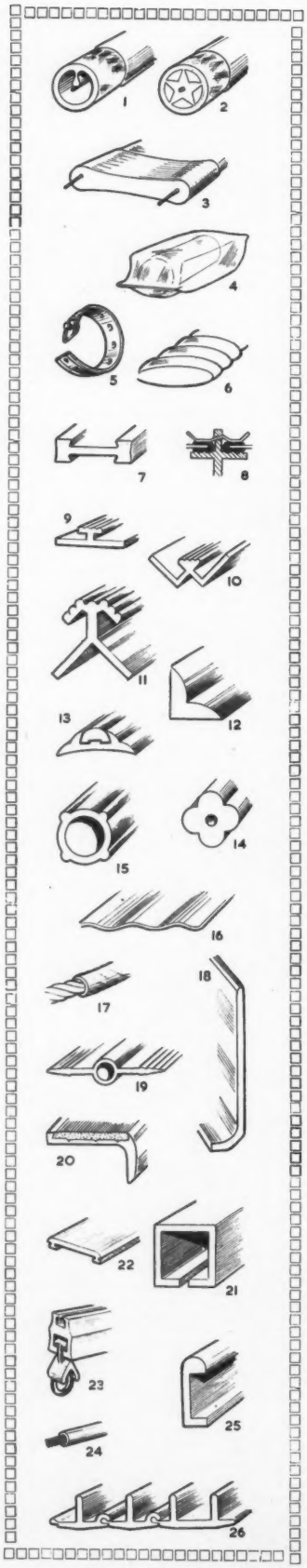
For lighting, transparent and translucent extrusions form fluorescent tube covers (27) and louvre strips. Solid or cored tubes are useful for table-lamp stands (29).

In household appliances, flexible beadings are used as bumpers on vacuum cleaners and as edging between washing machine panels. Rigid p.v.c. tube is formed into a crevice tube for vacuum cleaners. Refrigerator breaker strips are made in high impact styrene. They can be cheaper than injection moulded parts and re-entrant sections facilitate fixing. Such strips have been made by Ashdowns, British Moulded Plastics and by De La Rue (28). Depending on size, some 10-16-ft. is used per refrigerator.

For trays, a variety of sections are used for edging (30), for rails, and for handles. Coloured acetate strip (33) is wound as a tray surround, and is similarly wound or woven for a variety of basket work.

C. and C. Marshall have recently made an ingenious section in soft-grade p.v.c. for the Cronapress continuous bell push. The section supports a copper contact strip held in place by an inset channel. On pressing the strip the circuit is completed with a contact strip at the base of the metal surround. Considerable ingenuity was required in design and die-making to obtain a section to meet the requirements.

Wire-reinforced p.v.c. tubing as extruded by Bardex Engineering, Ltd. and Creators, Ltd.



is useful for flexible gas supply providing no high temperatures need to be withstood.

In the kitchen, a pot-scourer knitted from flat nylon ribbon is preferred to the steel-wool type which scratches the hand.

Clothes, Bags, Travel Goods and Fancy Goods

Immediately after the war when polyvinyl chloride extrusion material was released from the cable industry, large quantities of p.v.c. went to the manufacture of belting, braces, shoe straps, etc. Unfortunately, as with other applications of plastics, knowledge of processing and compounding was inadequate, with the result that products of poor quality reached the consumer market with inevitable after-effect of a serious reduction in demand. Only gradually are high quality belting and strapping finding their way back to those fields. Today's compounds are stronger, resistant to colour bleeding, and extrusions are available in many colours and designs. By means of embossing rollers and printing equipment in the take-off systems, designs such as those by Platex are obtainable (31, 32). The basket-type strip matches a p.v.c. sheet used in handbag manufacture; it is both embossed and printed. Using two extruders feeding into one die-head, such complex two-colour patterns as that from R. H. Windsor's sample collection (36) are possible.

Shoe-welting (35) in p.v.c. is very useful but care must be taken to formulate suitable compounds. This application is still under investigation by shoe manufacturers, extruders, and the Boot, Shoe and Allied Trades Research Association. Plastics sleeves can replace crimped metal for the tips of shoe-laces.

In making plastics bags, p.v.c. piping is used for joints and edge trimmings. An all-plastic slide fastener was introduced a few years ago by Flexigrip Co., Ltd. (34). It is extruded by C. and C. Marshall to very close tolerances. Some two million feet of this section is being used annually in the U.S.A.—and the Continent is not far behind. The advantages of this section are obvious; it is available in continuous lengths in any desired colour, is tough, weather- and rust-proof, can be sewn, is virtually air-tight; and is eminently suitable for high-frequency welding to p.v.c. sheet. Producing a flexible p.v.c. extrusion to the very fine limits allowed, called for precision die-making with watch-makers' tools.

Travel goods of all types make use of plastics beading, piping, etc., an attractive example being the maroon p.v.c. corner strips on the Rev-Robe set, made by W. Wood and Sons, Ltd., which stand proud from the surfaces of the cases, protecting them from wear.

Cellulose acetate rod is the starting material for the manufacture of beads for costume jewellery. Knitting needles have, of course, been extruded from casein for many years.

Agriculture and horticulture

Water-supply tubing in polythene and p.v.c. are of great help to the farmer because of the ease of laying (see p. 426, 427). One use of flexible Alkathene tubings is in the provision of fed pipes to moveable drinking troughs for strip grazing. Non-toxic grades of p.v.c. as well as polythene are fitted on many milking machines. P.v.c. garden hose is lighter and more durable than rubber hose. Greenhouse glazing with p.v.c. channels has been described in the section on building.

An ingenious use of p.v.c. strip is in the Rainbow tree tie. The flexibility of the material provides a firm grip for the branch without causing abrasion or other damage. It can expand as the tree grows. P.v.c. monofilament or covered wire has many uses in the garden. A method of taking cuttings from fruit trees consists of making a cut in the branch without severing it and wrapping it with soil kept in position by polythene film. Roots form near

the cut in a very short time and the cuttings can then be severed and planted.

Transparent cellulose acetate and cellulose acetate butyrate tubes have been used successfully for the artificial insemination of cows instead of glass, thus eliminating the grave risk of breakage. Since these materials will not stand up to sterilization in boiling water, they must be thrown away after use.

Chemical and Food Industries

Advantages of plastic tubing for conveying food and chemical products are discussed on page 426. Particular examples include effluent drainage, conveying acid to plating tanks, brine in bacon curing. A bottle filling machine recently described in *Plastics* (October, 1953) uses p.v.c. tubing, and acrylic rod for machining filling heads, valves, etc.

A special type of reinforced hose has been made experimentally by R. H. Windsor (37), using two of their twin-screw machines—one feeding flexible and the other feeding rigid p.v.c. tube. The resulting tube is flexible and is protected by an external spiral reinforcement of rigid material.

Polythene rods are used as stirrers, supports. A curious application is the provision by Rediweld, Ltd., of strips, 2-3 in. long, of semi-circular section which are used as floats on acid plating baths. The liquid surface is completely covered in this way and splashing is prevented without impeding insertion or withdrawal of plating jigs. Another recent fabrication by Rediweld makes use of polythene tubes for chromatographic analysis apparatus.

Where polythene or p.v.c. chemical equipment is being fabricated by welding, extruded rod is employed for sealing the joints, usually using hot gas welding torches to melt the plastic material. Prodorite, Ltd., and Rediweld, Ltd., are among the companies carrying out welding, whilst rod is supplied by Rediweld, Stanley Smith and Co., and Telegraph Construction and Maintenance Co.

Courlene polythene monofilament of 0.005 to 0.022-in. diameter is woven into acid-resisting overalls and is under investigation for filter cloths by Courtaulds, Ltd.

Engineering Components

Strip, beading, and many types of special sections, serve as gasket joints and edgings in engineering assemblies. Nylon gears can be machined from extruded rod. Many engineering tools require a liquid coolant and this is best supplied by p.v.c. or polythene tubes. Examples illustrated include cooling water for a high-frequency generator and for a welding torch. Plastics were chosen not only for toughness and durability, but for resistance to ozone generated in the welding process, which would attack rubber tubing. The light-transmitting properties of acrylic rod are employed in a probe illuminator made by Engineering Development (England), Ltd.

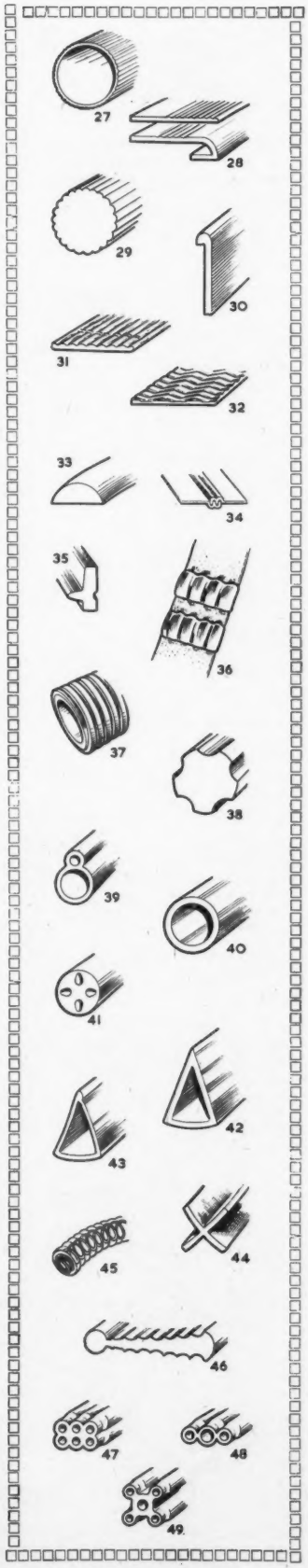
Tools

For tools, clear amber extruded cellulose acetate butyrate is machined to make screwdriver handles (38). Rod of this material, as well as of polythene, ethyl cellulose and cellulose nitrate is also employed in making hammer heads by Thor Hammer Co. Vietum shrink sleeving made by Lacrinoid Products, Ltd., is used to cover the handles of pliers, hammers and other tools.

Medical, Dental and Optical

Plastics tubing, made of specially pure compounds of polythene, p.v.c. and nylon, find many uses in medical and surgical work. Various sections are made by Portland Plastics, Ltd. (39, 40, 41), including the triangular section tubes (42, 43).

Ideally, all such resins employed should possess the following features:—



(1) Compatibility with human tissues, frequently in direct contact with the blood stream.
(2) Every degree of flexibility from semi-rigid to an extensibility of 1 in 4.
(3) Opacity to X-rays.
(4) Optical clarity.
(5) Non-kinking propensity, even when a thin-walled tube is sharply bent to negotiate a tortuous path, e.g. into the pelvis of the kidney via the urethra, bladder and ureter.
(6) Great tensile strength and toughness. It is no matter for amusement when a ureteric catheter breaks in the kidney and a dangerous operation is necessary to remove the broken part.
(7) Tolerance to repeated sterilization for 15 minutes in the autoclave at 140° Centrigrade, without physical change.
(8) Perfectly smooth or glossy surfaces inside and on the surface of the tube.
(9) Accurate dimensional cross-section throughout the entire length, whether the bore is 0.5 millimetres or 25 millimetres, and sometimes four variable bores in the same tube, in cross section.

No single resin possesses all these properties, but most of them can be found among nylon, polythene or p.v.c. and its copolymers.

One persistent problem, after extrusion, is the need to impart a gentle taper of, say, from five millimetres to three millimetres in a tube 18 inches long, with a smooth, olive-ended finish at one end and a wide flange at the other, to prevent its disappearance into the body. Lacking such a flange, a fine polythene tube recently disappeared into the axillary vein, before the nurse in attendance realized what was happening—and its whereabouts in heart or lung could not be determined by means of X-rays.

Administration of anaesthetics over prolonged periods is now regularly and safely carried out by means of extruded plastics, and on a large scale; plastic arteries and veins are featured in the wonderful "mechanical heart" developed at the Post Graduate School of Medicine, reformation of the pharynx by means of grafts on a plastic tube of special shape is fairly commonplace, blood transfusions by means of plastic tubing a regular practice, the administration of penicillin solution and other anti-biotics into the blood stream a standard procedure—and the deluge of demands for further and more delicate applications still grows.

Dental saliva ejectors, plastic nasal ducts, perforated "mastoid" drainage balloons to simplify and reduce the pain of frequent dressings, and tracheotomy tubes to replace metallic prototypes are recent advances, and the list grows larger as surgeons find the better medium in plastics, which glass, rubber and metal formerly tried to fulfil.

(The above interesting notes on the manifold uses of plastics extrusions in surgery have been supplied by Portland Plastics, Ltd.)

Nylon tubing, which can be sterilized in boiling water, is used for blood transfusions, both in civilian and military hospitals. Nylon monofilament is frequently used for sutures in place of gut.

Transparent Perspex rod is used by Vann Bros., Ltd., for making surgical instruments, such as retractors, in order to make use of the "light-piping" property of the material. An all-plastics stethoscope made by Hellermann Electric, Ltd., included flexible p.v.c. tubes.

For dental equipment the flexible drive for the dentists drill has been covered with p.v.c. to give a hygienic surface.

In hospitals, cellulose acetate and p.v.c. sleeving is favoured for covering rails, surgical trolley frames, etc. "Celastoid" tubings made by British Celanese, Ltd., is used by Porter (London), Ltd., for this purpose. A patented

curtain rail of cellulose acetate is designed by the manufacturers, Roanoid Plastics, Ltd., specifically for hospital cubicle equipment.

In optical work, a small but interesting application of p.v.c. extrusion is the use of a small-bore sleeving to protect lenses of rimless glasses from abrasion or shock, by preventing direct glass-to-metal contact, where the fixing rivet pierces the lens.

T. J. Smith and Nephew, manufacturers of Elastoplast extrude a plasticized p.v.c. sheeting for use in water-proof dressing as an alternative to production by calendering. Rigid p.v.c. tube and an ×-section (44) are cut into cores for winding bandages. The latter design is for efficient wetting of Plaster of Paris bandages when these are immersed, water penetrating easily between the interstices between the bandage and the arms of the ×-section.

Transport

Feed pipes for petrol and Diesel fuel oil are made from pure or reinforced p.v.c., one type being the transparent wire-reinforced Bardex pipe (45). Other types are made by Wilkinson Rubber Linatex, Ltd., and Creators, Ltd.

Electrical wiring systems in cars and aircraft must be grease-, petrol- and oil-resistant, so only p.v.c. insulation and sleeving is suitable. Special multi-way connectors are made by Ripaults, Ltd., from extrusions supplied by Bardex Engineering, Ltd. (47, 48, 49).

Wing piping, for sealing the joints between adjacent car panels are made by most extruding companies from flexible p.v.c. in many colours. The section shown is by Tenaplas, Ltd. (46). Handrails in public vehicles are covered with cellulose acetate tube or spirally wound with ribbed acetate tape by Dover, Ltd. (50). Steera-grip (55) is a flexible p.v.c. channel made by Creators, Ltd., for fitting over steering wheels to improve the grip.

In bicycles and motorcycles p.v.c. sleevings are used for handle grips. Cycle-brake wires run in a p.v.c.-covered sheath. Bicycle pumps are made from celluloid or c.a.b. extrusions by B.X. Plastics, Ltd.

Cellulose acetate butyrate retainer strips are used in aircraft in a patented method of fixing p.v.c. leathercloth wall panelling. The edge of the cloth is wedged between the cap section (52) and the screw-mounted member (53). There are three types of panel strips: single (53), double (54) and double with curtain rail (51). The sections, which must be made to very close tolerances, are extruded by De La Rue for the major air lines.

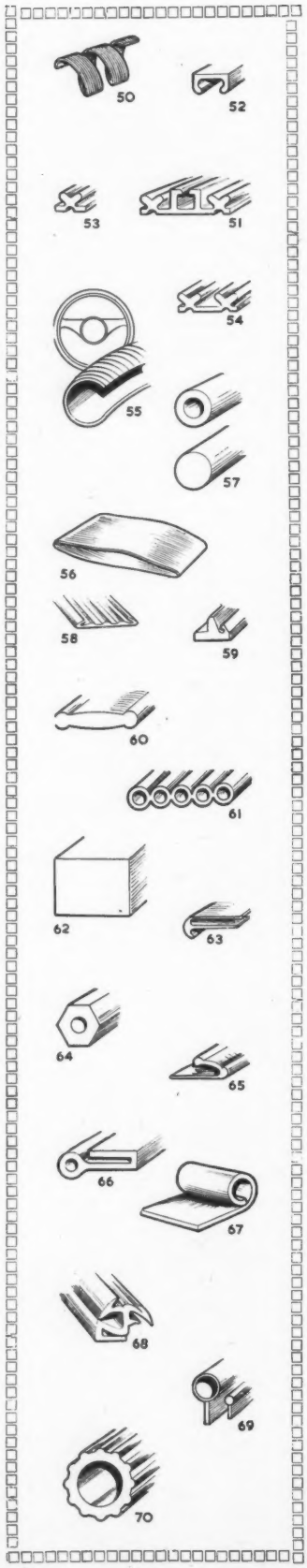
Uses of plastics in boats and ships correspond generally to those dealt with for building and interior furnishings. Roanoid Plastics, Ltd., in particular, supply metal-reinforced cellulose acetate extrusions for railings, luggage racks, curtain rods, etc.

New rolling stock for British railways is extensively panelled with decorative laminates and plastics coverstrips are used for edgings and corners. A recent production of Ashdowns, Ltd., is a drip-tray for railway-carriage doors fabricated from a p.v.c. moulding with extruded p.v.c. drain tubes welded in place.

In railway signalling equipment cellulose acetate sleeving is used for covering signal levers and smaller sleeving is hot-stamped for cable terminal identification tags. Clear acrylic rod is used by Westinghouse Brake and Signal Co., Ltd., to "pipe" light from indicator bulbs to a signal control panel.

Office Equipment

The Dictaphone dictating machine records its message on a thin tubular belt extruded from red transparent cellulose acetate butyrate (56). The Dictaphone, as well as another dictating machine, the Emidicta, makes use of rigid plastics tubes for ear-phones of the stethoscope type. Lightness is of great advantage here.



Fountain pens, ball-point pens and propelling pencils are machined from tubes and rods of ebonite, casein, cellulose nitrate, cellulose acetate and cellulose acetate butyrate. To form cylindrical pen bodies or caps with solid ends a piece of rod is cemented to a tube before machining to the required shape (57). Such rods and tubes are made by B.X. Plastics and De La Rue.

More recently with the introduction of the ball-point pen, thin tubes of acetate and polythene (about 1/10-in. diameter) are used as ink containers. De La Rue have extruded over 15,000 miles of tubing for this application alone.

Phenolic tubes are extruded by Gestetner, Ltd., for making the inking rollers for their duplicating machines. Another use of extruded phenolic tubes is in a pneumatic tube conveyor system used by British Railways at Fleetwood. Several hundred feet of Rockite tubing (made by British Resin Products, Ltd.) has been in constant use for many years. A more recent installation by Lamson Engineering Co., Ltd., for a Government Department uses transparent cellulose acetate tubing of 1-in. diameter extruded by B.X. Plastics. Carriers for the Lamson tubes are fabricated in different sizes from transparent acetate tubing. Lamson's are now investigating rigid p.v.c. as a replacement for their steel tubes and experimental lengths have already been installed.

In filing cabinets plastics channelling enables easy and silent movement of drawers.

Toys and Games

Considering the extensive applications of plastics in toy-making, little use has been made of extruded plastics in this field. A building set made by E.V.B. Plastics used cellulose acetate tubes to connect the moulded "bricks." Another use is the cellulose acetate butyrate roller shutter strip made by Rolinx, Ltd., for their pencil boxes, paint boxes, etc.

White flexible p.v.c. tape is made by several extruders for tennis court marking (67). Other sports applications include Vietum sleeving for the handles of golf clubs, cricket bats, etc.

Display and Packaging

Plastics-covered tubes and wires are used extensively in the construction of displays. Another use in shop fittings is for hosiery display legs, which are formed by blow-moulding transparent cellulose acetate tubing.

Melwood Thermoplastics have produced a number of extruded sections for different types of price-markers. Both the wall-mounted type and the free-standing type are of rigid p.v.c. (58, 59). Transparent cellulose acetate tube is used to make containers for toothbrushes and similar types of packs. A great variety of shapes is produced by De La Rue.

The Rado packaging system developed by Technopol Laboratories, Ltd., enables liquids and pastes to be packed in sachets sealed off individually from a continuous p.v.c. tube. Such sachets have been used as unit packs for shampoo, hair-dye, adhesives, etc.

The applications of polythene film, layflat tubing and bags as well as of polythene-coated paper, card, cork and metal foil have been described on page 430.

Miscellaneous

Some typical sections made by leading custom extruders are shown in the drawings (61-70). The drawings and photos shown on the foregoing pages have shown varied applications of plastics extrusions in the major industries. There are, of course, many more that have not been described, but the properties of extruded plastics and the advantages to be gained from their use have been indicated.

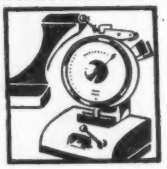
DIRECTORY OF PLASTICS EXTRUDERS

Principal companies carrying out the extrusion of plastics materials are shown below. The main products of each company are indicated. The centre column shows by means of a (*) those companies which are prepared to undertake plastics extrusion to customers' requirements.

COMPANY	Extrude to customers' requirements	PRINCIPAL PRODUCTS
Aerialite Ltd., Stalybridge, Cheshire	—	Cables: polythene-insulated, p.v.c.-sheathed for h.f. and high voltage.
Ashdowns Ltd., St. Helen's, Lancs	*	Thermoplastics section—e.g., high-impact polystyrene refrigerator breaker strip.
Associated Technical Manufacturers Ltd., New Islington, Manchester, 4	—	Special grade p.v.c. insulating sleeving, cables, wires and sections.
B.X. Plastics Ltd., Chingford, London, E.4	*	Tubes and rods, including cellulose nitrate, cellulose acetate, ethyl cellulose, casein, acrylic rod, polystyrene foil, etc., p.v.c. sections.
Barclay-Stuart (Plastics) Ltd., 25–27, Brunswick Street, Luton, Beds	*	Thermoplastic tube, rod, sections for industry.
Bardex Engineering Ltd., Chertsey, Surrey	*	Bardex wire-reinforced petrol pipe, sleevings, covered curtain wire, etc., in plasticised p.v.c.
British Cellophane Ltd., 12–13, Conduit Street, London, W.1	—	Regenerated cellulose film, polythene film and lay-flat tube.
British Celanese Ltd., Hanover Square, London, W.1	—	Cellulose acetate sheets, rods, tubes and sections.
British Insulated Callenders Cables Ltd., Norfolk Street, London, W.C.2.	—	All types cable, including p.t.f.e., silicone and polychloroprene-insulated.
British Moulded Plastics Ltd., Walthamstow Avenue, London, E.4	*	Thermoplastic tubes and sections, including rigid p.v.c. pipe (for Prodorite, Ltd.).
British Resin Products Ltd., 21, St. James's Square, London, S.W.1	*	Phenolic rods, tubes and sections.
Capon, Heaton and Co. Ltd., Stirchley, Birmingham, 30	*	Natural and synthetic rubber and plastic sections.
Cascelloid Ltd., Abbey Lane, Leicester	—	Polythene bottles, packaging film and tube.
Cheltenham Plastics Ltd., Crawley, Sussex	*	P.v.c. sleeving, p.v.c. and polythene tubes and sections.
Chemical Pipe and Vessel Ltd., Godstone Road, Kenley, Surrey	—	Rigid p.v.c. and polythene tubes up to 10–12-in. diameter.
Chiltern Paper Products Ltd., Hemel Hempstead, Herts	—	Polythene film, lay-flat tubing and polythene-coated paper.
Clyde Paper Co. Ltd., Glasgow	—	Polythene film and lay-flat tube.
Commercial Plastics Ltd., 1, Avery Row, Grosvenor Street, London, W.1	*	Polythene film and lay-flat tube to 30-in. diameter, flexible p.v.c. sections.
Coventry Motor and Sundries Co. Ltd., Spon End, Coventry	*	Semi-rigid and flexible p.v.c. tube, rod and sections.
Creators Ltd., New Haw, Weybridge, Surrey	*	Steel-wire reinforced hose, steering-wheel covers, garden hose, multi-core tube covered wire in p.v.c.
Day, J., and Co. (Derby Works) Ltd., Harrow Manor Way, Abbey Wood, London, S.E.2.	*	Cables, wires, flexibles, sleevings, etc., in p.v.c. and polythene.
De La Rue, Thomas, and Co. Ltd., 84–86, Regent Street, London, W.1	*	Sections in rigid and flexible p.v.c., polythene, cellulose acetate and acetate butyrate, ball-pen tubes, tubular containers, pen and pencil blanks, roller shutters, drain tubes.
Dover Ltd., Northampton	—	Cellulose acetate strip and tube for tube and rail covering.
Duratube and Wire Ltd., Faggs Road, Feltham, Middx.	*	Polythene- and p.v.c.-insulated cables; p.v.c. tubes, sleeves, sections, including belts and concrete expansion joints.
Edison Swan Electric Co. Ltd., 21, Bruton Street, London, W.1	—	Experimental extrusion of p.t.f.e. rod and tube
Ever Ready and Co. (Gt. Britain) Ltd., Hercules Place, London, N.1	—	Battery containers, sleeving.
Erinoid Ltd., Stroud, Glos	*	Casein, cellulose acetate; rigid and flexible p.v.c. tubes, rods, sections; rigid pipe to 6 in. diameter; electrical conduit: concrete water stop.
Gestetner Ltd., Tottenham, London, N.7	—	Phenolic tubes for internal use as ink rollers.
Geipel, William, Ltd., 156–170, Bermondsey Street, London, S.E.1	—	Wires and cables.
Greenwich Leathercloth Co. Ltd., St. Mary Cray, Kent	—	P.v.c. garden hose, pipes, transparent thin-wall tubing and sleeving.
Hartley, V. and N. Ltd., Greenfield, nr. Oldham, Lancs	—	P.v.c. glazing channel for internal use in greenhouse construction.
Hawkhead, Bray and Son Ltd., Phoebe Lane Mills, Halifax	—	P.v.c. tubes for cistern flush pipes.
Henley's, W. T., Telegraph Works Ltd., 51–53, Hatton Garden, London, E.C.1	—	Cables and wires.
Imperial Chemical Industries Ltd. (Plastics Division), Welwyn Garden City, Herts.	—	Polythene tubing for water and chemical industry, polythene film, Terylene polyester film.
Jackson, Henry (Liverpool) Ltd., 65, Admiral Street, Liverpool, 8	—	Polythene film and lay-flat tube.
Johnson and Phillips Ltd., Victoria Way, Greenwich, S.E.7	—	Cables.
Lacrinoid Products Ltd., Gidea Park, Essex	—	P.v.c. shrink sleeving for rail and handle covers, rigid p.v.c. tubing, p.v.c. and polythene bottles.
"Lustrac" Plastics Ltd., Hyde Way, Welwyn Garden City, Herts	*	Unplasticized p.v.c. rod and tube, $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. diameter.
Marshall, C. C., and Co. Ltd., Oakleigh Road North, London, N.20	*	Special sections for motor and other trades, wing piping, bag beading, sleevings etc., principally in flexible p.v.c.
Melwood Thermoplastics Ltd., Harpenden, Herts	*	Rigid and flexible p.v.c. sections and tubes to 6-in. diameter, terrazzo flooring strip, floor coving, stair nosing.
Metropolitan Electric Cables and Construction Co. Ltd., Chadwell Heath, Essex.	—	P.v.c. and polythene-insulated wires and cables.
Mills, L. N., Ltd., New Malden, Surrey	—	Plastics-covered curtain wire.
Phoenix Rubber Co. Ltd., 2k, Buckingham Avenue, Trading Estate, Slough.	—	P.v.c. garden hose, extrusion straining for purification of scrap material.
Phoenix Telephone and Electric Works Ltd., Hendon, London, N.W.9.	—	Cables and wires
Pirelli-General Cable Works Ltd., Southampton	—	Cables, multi-way p.v.c. tubing for gas or liquids.
Plasticable Ltd., Hawley Lane, Farnborough, Hants	*	Sleeving, gasketing sections, p.v.c. sheathing of copper and iron pipes.
Platex, 66–67, High Street, Brentford, Middlesex	*	Custom extrusion of thermoplastics, embossed p.v.c. strip and braided mats
Plextrude Ltd., Murrels Lane, Frimley Road, Camberley, Surrey	*	Rigid and flexible p.v.c. sections.
Plysu Products Ltd., Woburn Sands, Bletchley, Bucks	—	P.v.c. extrusion for use within the organization.
Portland Plastics Ltd., New Hythe, Kent	*	Special extrusions for medical and surgical use.
Prodorite Ltd., Eagle Works, Wednesbury, Staffs	—	Suppliers of polythene and rigid p.v.c. tubes for chemical use.
Redfern's Rubber Works Ltd., Hyde, Cheshire	*	Sections in rubber and ebonite.
Rediweld Ltd., Crompton Way, Crawley, Sussex	*	P.v.c. and polythene tube, rod and sections for chemical plant, welding rod for fabricators.
Rist's Wires and Cables, Ltd., Lower Milehouse Lane, Newcastle, Staffs	—	P.v.c. wires and cables, sleeving and sections.
Roanoid Plastics Ltd., Kings Road, Tyseley, Birmingham, 11	—	Cellulose acetate covered metal stair rails, curtain rods, etc.
Rolinx Ltd., 13, Blossom Street, Ancoats, Manchester	—	Roller shutter extruded from cellulose acetate butyrate for pencil boxes, etc.
Rowlands, S., Ltd., 19, Grange Road, London, S.E.1	—	Plastics-insulated cables.
Rubber Improvement Ltd., Willesden, London, N.W.10	*	P.v.c tubes and sections.
St. Helen's Cable and Rubber Co., Slough, Bucks	—	Cables and wires.
Siemens Bros. and Co. Ltd., Woolwich, S.E.18	—	Cables and wires.
Smith and Nephew Ass. Cos. Ltd., Neptune Street, Hull, Yorks	—	Plasticized p.v.c. film for waterproof bandages, p.v.c. cores for bandage rolls.
Smith, Stanley and Co., Isleworth, Middx.	*	P.v.c. and polythene rods, tubes and sections.
Standard Telephones and Cables Ltd. Corporation Road, Newport, Mon.	—	Plastics-insulated wires and cables, polystyrene insulation.
Spesco (Development) Ltd., 195, Uxbridge Road, Hampton Hill, Moseley, Surrey.	—	Polythene film.
Sufiex Ltd., 35, Baker Street, W.1	*	P.v.c. cables, sleeving and sections.
Telegraph Construction and Maintenance Co. Ltd., Greenwich, London, S.E.10.	*	Polythene-insulated cables, polythene tubes, rods, etc., polythene-coated paper.
Tenaplas Ltd., Upper Basildon, Berks	*	P.v.c. and polythene tubes to 12-in. diameter and sections.
Todd, D. G., and Co. Ltd., Southport, Lancs	*	P.v.c. beading and piping for internal use.
Transparent Paper Ltd., 6, Arlington Street, St. James's, London, S.W.1	—	Regenerated cellulose film, polythene film and lay-flat tube.
Transradio Ltd., 138a, Cromwell Road, London, S.W.7	*	Polythene-insulated, p.v.c.-sheathed, air-spaced co-axial cables, custom extrusion.
Wade, J. J. (London) Ltd., 3, Duke Street, S.W.1	—	Polythene tube to 6 in. diameter.
Wandleside Cable Works Ltd., 106, Garratt Lane, Wandsworth, London, S.W.18	—	Wires, cables and sleeving, p.v.c.- and polythene-insulated.
Ward and Goldstone Ltd., Frederick Grove, Pendleton, Manchester, 6	—	P.v.c. cables, sleeves, beading and sections.
Wills, Arnold and Co. Ltd., Uppingham, Rutland	*	Flexible p.v.c. belting for clothing, etc.
Wilkinson Rubber Linatex Ltd., Frimley Road, Camberley, Surrey	—	Reinforced p.v.c. petrol pipes.

World's Industry Employs Plastics

MATERIALS and TESTING



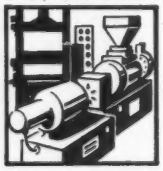
New sheet material is said to have good low - cost forming characteristics. Campco S-300 is a copolymer of polystyrene and rubber extruded through special equipment in a single operation.
(*Automotive Industries*, 1953/Sept. 15/72.)

Kinetics of phenol-formaldehyde reactions.—S. N. Sahai and M. S. Bhatnagar report on their studies on the kinetics of reaction between phenol and formaldehyde at pH 10 and 20° C. Three types of reactions take place between the two compounds resulting in the formation of three products.
(*Journ. Scientific and Industrial Research* (India), 1953/Aug./B378.)

Rubber-plastic materials.—Ace-Flex is a lightweight plastic material of good electrical properties and chemical resistance, supplied as flexible tubing and sheet material. Riviclor is an unplasticized thermoplastic of good chemical resistance and impact strength useful for pipes, fittings, tank linings, etc. Dur-Ace is a thermoplastic, multipolymer material of high impact strength and dimensional stability suitable for formed and draw-moulded parts.
(*Automotive Industries*, 1953/Sept. 1/146.)

Versatile silicone resin.—A new insulating varnish by General Electric Co. is said to have an unusual combination of heat resistance, low-temperature flexibility and high bonding strength, useful for electric insulation and as a varnish.
(*Wire and Wire Products*, 1953/Oct./1127.)

PROCESSES : MACHINERY



Extrusion of nylon.—Members of the field service laboratory polychemicals department, of E. I. du Pont de Nemours and Co., give an illustrated survey of nylon extrusion techniques for rods, tubing, wire coating, etc., pointing to special requirements of screw and die design and special equipment to handle this material.
(*Modern Plastics*, 1952/Aug./99-108.)

Extrusion of polystyrene.—Polystyrene is excellent for extrusion when care is exercised in (1) selection of material, (2) design of extruder elements including the die, (3) selection of cooling, take-away and draw rolls, (4) use of appropriate cut-off devices.
(*Tool Engineer*, 1953/Sept./134.)

Mechanized handling of plastics.—At the Warren plant of Sylvania Electric Products Inc., completely automatic compression and injection moulding machines are installed supported by an automatic handling of the material by conveyors. All manual handling is for positioning purposes only and performed with a minimum of manual movement.
(*Tooling and Production*, 1953/Sept./56.)

Teflon moulding.—New moulding techniques have been developed for Teflon (fluorocarbon polymer) for producing parts with varying wall thicknesses, tapers and undercuts.
(*Instrument Manufacturing*, 1953/May-June/96.)

Thread tolerances.—Suggestions for tolerances for moulded plastic components with metric thread are given by E. C. Kopanovich.
(*Vestnik Mashinostroenija* (Russia), 1953/Mar./73.)

INDUSTRIAL APPLICATIONS

Nylon-covered wire ropes. — High - tensile steel strands covered with a hard jacket of transparent nylon protect the core from corrosion and increase fatigue resistance up to five times. The ropes are marketed under the name "Wirelon" by Rochester Ropes Inc., Culpeper, Virginia.
(*Wire and Wire Products*, 1953/Oct./1095.)

Neoprene wire coverings.—Laboratory and outdoor tests have shown that neoprene coverings stand up very well both in physical and electrical tests to weathering and may give many years of trouble-free service.
(*Wire and Wire Products*, 1953/Oct./1047.)

Fluorothene in wire and cable manufacture.—A general survey as presented at the 1953 Annual Convention of the Wire Association shows that this new plastic has many favourable properties for cable coverings.
(*Wire and Wire Products*, 1953/Oct./1069.)

Plastic ball-bearing retainer.—Precision bearings capable of speeds over 100,000 r.p.m. have been made possible by thermosetting laminated plastics fabricated into retainers. These are made for single row, deep groove, etc., bearings.
(*American Machinist*, 1953/17/157.)

Correct selection of plastics.—Useful hints for engineers are given on choosing the correct plastic from the large number of types and qualities offered.
(*McGraw Hill Digest*, 1953/Sept./22.)

Plastics speed toolmaking work.—Survey of applications of plastics for cast or laminated tools. It is expected that next year's automobiles will have tooling programmes speeded up by glass laminate-coated assembly and chucking fixtures.
(*Iron Age*, 1953/Aug. 6/136, *McGraw Hill Digest*, 1953/Oct./52.)

Plastic hole plugs.—A large variety of sizes are available to shape easily into round or square holes provided for facilitating assembly operations. Plugs are pressed into position without special tools.
(*Automotive Industries*, 1953/Sept. 1/144.)

Plastic spraying.—H. M. Denn discusses the importance of metal and plastic spraying in the electricity supply industry and gives numerous examples. Busbars and other high-voltage equipment, including supporting steel framework for insulators carrying high-voltage lines and the inside of junction boxes, have been effectively insulated by spraying with polythene.
(*Electroplating*, 1953/Oct./391.)

Plastics in automobile and aircraft design.—At the occasion of the advent of the first plastics bodies appearing on the market (Chevrolet Corvette) an American magazine gives a survey of all plastics components incorporated in the modern motor car.
(*Automotive Industries*, 1953/Sept. 15/42.)

Laminated plastic nuts are suggested by V. N. Lymzin as an improvement over the bronze nuts hitherto used for lead screws on machine-tools.
(*Vestnik Mashinostroenija* (Russia), 1953/Mar./21.)

MISCELLANEOUS USES

French plastics manufacture.—New manufacturing plants for plastics materials, built in France include a Terylene plant by Société Rhodiaceta under I.C.I. licence, a silicone plant (in co-operation with Dow Corning) and cellulose based plastics by Ciscorasa formed recently by Visking Corporation of Novacell S.A. of Paris. The polythene plant of Ethylene Plastique under I.C.I. licence is to start production before the end of this year and should reach an output of 2,000 tons in 1954.
(*Chemical and Engineering News*, 1953/Oct. 26/4448.)

Art restorations.—Geon vinyl latex has been used by F. W. Dolloff of the Museum of Fine Arts, Boston, for restoring and preserving old prints and drawings. After a complicated cleaning process the damaged work is pasted together and sprayed with a clear transparent latex.
(*Rubber Age*, 1953/Oct./83.)

Adhesives and sealing compounds.—W. J. Clayton and R. K. Humke give a survey on rubber-base compounds which offer a wide range of applications.
(*Machine Design*, 1953/Aug./260.)

Plastic and ceramic dinnerware.—R. W. Cline and E. Schramm represent an interesting discussion on the merits of each type. It is concluded that from the health point of view chinaware is more desirable.
(*Am. Ceramic Soc. Bulletin*, 1953/Oct./349.)

Plastics progress in India.—Survey of the development of the young plastics industry dealing with: raw materials, resins and moulding compositions, adhesives and laminates, alkyd resins.
(*Journ. Scientific and Industrial Research*, (India), 1953/Aug./A361.)

LETTERS TO THE EDITOR

Correspondents are reminded that a stamped and addressed envelope should be enclosed in all cases where a personal answer is desired. It is understood that any letter received may be published at the discretion of the Editor.

The Problem of Scrap

Sir,—Your editorial and correspondence on "scrap" will undoubtedly be of considerable interest to all those engaged in the administration of the moulding section of the industry.

The majority of your correspondents appear to deal in the main with the waste and reclamation of moulding material. Surely, without minimizing this aspect, it is the waste of labour, loss of overheads and useful machine utilization which causes the greatest loss to each individual factory, to the industry generally and the nation as a whole.

It has been stated that mistakes cost this country millions of pounds annually. In general, material amounts to less than half of the cost of scrapped components and this scrap material, even after "regeneration," as Dr. Yarsley describes it, is only worth approximately one-third of its virgin price, but in order to get it into this state further expense has to be incurred by the use of vital labour. The problem, as I see it, is one of prevention rather than correction, and much more can be done to achieve the former by ensuring the highest possible engineering standards as far as tool design and manufacture are concerned and by the adequate training of labour. If engineers and supervisors can be encouraged to give more attention to these aspects of production there would be a marked reduction in the scrap content.

Serious attempts were made during the war to pay particular attention to the training of supervisory staff and subsequently, of course, the operators, and it is time, in my opinion, that further attention is given to this important problem. I know that a lot of work is going on but employers should be encouraged to take the fullest advantage of the services available. It is inconceivable that anyone, from the humblest shop boy upwards, obtains any satisfaction from the production of faulty work, even if the employee's wage packet is unaffected. Today I believe that individual members of any organization take an intense pride in the achievements of the particular company by whom they are employed, and I have found that if the employee is given clear-cut, precise instructions, with ample facilities for doing his job correctly, he will do it with relative improvement in the general production position.

Many plastics firms have what is sometimes described as "renovation departments." It is generally conceded that these departments recover some proportion of the scrap produced, particularly in connection with large thermosetting mouldings, but it is very doubtful whether individual firms ever closely assess the economics connected with such recovery.

Scrap is a problem which will always be with us, but if the above recommendations are carried out it can be controlled to reasonable economic limits.

D. RADFORD,
Executive Director.

E. K. Cole, Ltd.,
Plastics Division,
Ekco Works,
Southend, Essex.

Magnetic Tapes

SIR,—We refer to your article on the manufacture of magnetic recorder tapes in which it is stated that hard p.v.c. film is not yet available in the United Kingdom, we would like to draw your attention to the fact that we supply hard p.v.c. film unplasticized from 1/000 up to 9/000 clear, transparent coloured and opaque coloured, in continuous reels as well as converted and laminated.

The film is also available in a prestretched grade, which is being tried experimentally as a base for recording tapes, and for other special applications.

KEMITYPE, LTD.

8 Chase Road,
London, N.W.10.

PROBLEMS AND TRENDS OF MODERN SCREW EXTRUDERS

(*Continued from page 409*)

indication in support of the above, the following examples could be mentioned:—

(a) By varying the helix angle of a 2½-in. screw, 11 : 1 length diameter ratio, 2 : 1 compression ratio, by only 1°, the output was increased from 96 lb. an hour, at 100 r.p.m. screw speed to 121 lb. an hour, with plasticized p.v.c. Increase 26%.

(b) A fully flighted 2½-in. screw with 2 : 1 compression ratio, 16 : 1 length diameter ratio, single start, water cooling full length of screw, designed for use with unplasticized p.v.c., had an output of 78 lb. an hour at 40 r.p.m. screw speed with unplasticized p.v.c., and 58 lb. an hour on polyethylene. Increasing the compression ratio and decreasing the length of water cooling within the screw, the polyethylene output was increased to 82 lb. an hour at 40 r.p.m. screw speed. Increase 41.5%.

(c) By careful attention to screw details such as land radii, surface finish, it is possible to redistribute the heat generation caused by mechanical work, along the compression zone of the screw. This will, of course, avoid undue temperature rise at any one point, thus allowing an increase in the maximum screw speed at which good quality extrusion can be expected. The curves shown in Figure 2 are self explanatory, but to select one example:—

Screw—2½-in. diameter. 16 : 1 length diameter ratio. 2 : 1 compression ratio. .004-in. screw clearance on diameter. Smear Head = .0625 clearance on diameter. Material = Polystyrene premix. At 70 r.p.m. screw speed, output = 90 lb. per hour. At 100 r.p.m. screw speed, output = 109 lb. per hour. Increase 21%.

The diagram on Fig. 2 shows output characteristics of four screws, each designed for one particular material and for an extruded section of .2117 sq. in.

The writers are convinced that with meticulous screw design the provision of a robust drive mechanism and accurate temperature control, the output and the quality of extrusion can be considerably improved upon.

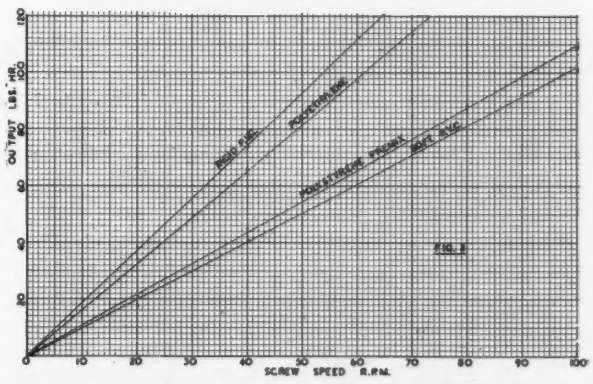


Fig. 2.—Effect of screw speed on extruder output with screws designed for specific materials.

Plastics NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

FEDERATION NEWS.—New members of the Raw Material Suppliers Group are Central Asbestos Co., Ltd., and Hariesti Mill, Ltd.

Mr. A. R. Crew, manager of advertising, Monsanto Chemicals, Ltd., and Mr. R. MacDonald Watson, publicity manager, B.X. Plastics, Ltd., have been co-opted to the publicity committee of the British Plastics Federation. Mr. M. W. Jude has resigned from the committee on leaving British Industrial Plastics, Ltd. Other members of the publicity committee are: Mr. W. M. York (E. K. Cole, Ltd.), chairman; Mr. D. H. Balfry (Industrial Mouldings (Warwick), Ltd.), Mr. P. A. Delafield (British Resin Products, Ltd.), Mr. C. S. Dingley (British Industrial Plastics, Ltd.), Mr. A. E. Skan (Tufnol, Ltd.) and Mr. P. I. Smith (I.C.I., Ltd.).

EIGHTH SWEDISH PLASTICS CONFERENCE.—Visitors from all over the world attended the Conference on November 19 and 20 convened by the Swedish Plastics Federation. Amongst the subjects discussed during the extensive programme were vinyl plastics, polyester glass-fibre reinforced structures, raw materials, and processing techniques.

Mr. Cyril Dingley represented the British Plastics Federation and was one of the 16 British delegates, namely, Mr. D. S. Mahon, Bakelite, Ltd.; Mr. H. A. Brooks and Mr. J. Butler, British Industrial Plastics, Ltd.; Mr. A. R. Henning, Fibreglass, Ltd.; Mr. F. Brown, James Day (Machinery), Ltd.; Mr. C. Schoofield, Fothergill and Harvey, Ltd.; Mr. M. Jones and Mr. H. B. Martin, Imperial Chemical Industries, Ltd.; Mr. P. Spiro, London and Scandinavian Metallurgical Co., Ltd.; Mr. F. Parmenter, Monsanto Chemicals, Ltd.; Mr. C. W. Welch, *Plastics*, Temple Press Ltd.; Mr. E. Gaspar, Projectile Engineering Co., Ltd.; Mr. B. Parkyn. Scott Bader and Co., Ltd., Dr. M. A. Matthews, Shell Petroleum Co., Ltd.; and Mr. F. G. Brabner, Vinyl Products, Ltd.

Visitors from abroad were the guests of the Swedish Plastics Federation on the Thursday evening at a celebration dinner, having previously attended a cocktail party at the home of Mr. Harry Nyström, chairman of the Swedish Federation. At the dinner, Mr. Dingley replied on behalf of the British visitors and the British Plastics Federation, to an address of welcome made by Mr. Nyström. Mr. Dingley, after offering the fraternal greetings of the British Plastics Federation, went on to thank the Swedish Federation for the hospitality which had been accorded to the British visitors, and to compliment Mr. Jan-Erik Janson on the excellent conference arrangements.

The conference offered a valuable opportunity for the consolidation of old friendships and the making of new ones and a fuller account of the proceedings, together with details of some of the papers read, will be published in the January issue of *Plastics*.

UNIVERSAL METAL PRODUCTS, LTD.—The Lancashire trade moulders and manufacturers of collapsible tubes have now their new injection moulding plant in Southport in full swing. A range of presses up to 16-oz. capacity is now installed, and this capacity is to be increased to 32-oz. presses very shortly. One of their latest productions is for a new type of battery manufactured by Oldham and Sons, Ltd., of Denton, one of which was installed on the Canberra bomber flown by Flt. Lt. Burton who won the speed section of the recent England/New Zealand Air Race. The construction of these batteries is based on a new type of plastic cell construction made from a specially developed material (Distrene 500 made by British Resin Products, Ltd.). The mouldings themselves were developed by Universal Metal Products, Ltd., in conjunction with Oldhams and are being moulded at Southport. It is interesting to note that each battery contains 30-oz. injection mouldings produced on presses ranging from 4-oz. to 16-oz. capacity.

The Editor and Staff of "Plastics" extend Christmas Greetings and Good Wishes for the New Year, to their readers at home and abroad

A NEW TIME INTERVAL METER.—Camerer Cuss and Co. announce a new meter developed by them in association with Allied Electronics, Ltd. The advantages claimed for the instrument include its self-contained structure and its simplicity of operation. The power is provided by two standard deaf-aid dry batteries making it portable and independent of mains and any errors introduced by mains frequency. Times can be recorded automatically by means of a standard N.P.L. stop-watch and resetting can be remotely controlled if required. Full details of this instrument are obtainable from the company at 56 New Oxford Street, London, W.C.1.

RIGID P.V.C. SHEETS. — Advance information has been received of rigid sheet manufactured by Bakelite, Ltd., under the trade name of Vybak. The bulletin identifies physical properties and details a considerable number of welding and machining techniques. Further details can be obtained by communicating with the manufacturers at 12-18 Grosvenor Gardens, London, S.W.1.

INDIA.—Mr. A. V. Johns, of 11/I.C. Harrington Street, Calcutta, is interested in obtaining agencies of United Kingdom manufacturers of plastic skin manufactured from the vinyl group of plastics. Mr. Johns covers Calcutta, West Bengal, Assam and Uttar Pradesh and is considered to be a suitable connection for U.K. manufacturers. (Board of Trade, Export Inquiry ESB/7413/53.)

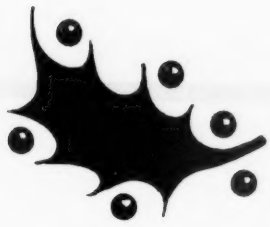
FIFTH BRITISH FURNITURE EXHIBITION.—Running in London from February 15-25 next year will be one of the biggest fairs yet sponsored by the British Manufacturers' Federated Associations. Nearly 300 manufacturers are expected to take part. Floor space occupied will be 16,000 sq. ft. more than this year.

NEW GRADES OF CARBON BLACK TO BE MADE IN BRITAIN.—Arrangements have been made for the manufacture, in the United Kingdom, of Kosmos and Dixie grades of Furnace Carbon Black previously produced only in the U.S.A. This was announced by Mr. Oscar Nelson, president of United Carbon Co., Inc., Charleston, West Virginia, on the eve of his departure from Europe at the conclusion of a prolonged visit. A long-term agreement has been reached whereby United Carbon Co., Inc., is making its technical knowledge and engineering experience available to United Carbon Black, Ltd., Swansea, for the purpose of establishing standards and ensuring control of quality. The modifications now in progress will result in the production of a general purpose furnace black to be marketed as Dixie 45 and Kosmos 45 by the selling agents of United Carbon Co. Inc., namely, Anchor Chemical Co., Ltd., and Chance and Hunt (a section of Imperial Chemical Industries, Ltd.). It is planned to produce other types of furnace black similar to the grades manufactured by United Carbon Co., Inc., in the U.S.A. These arrangements will enable customers of United Carbon Co., Inc., to obtain prompt delivery of furnace blacks of the highest quality against payment in sterling.

INTERNATIONAL PLASTICS EXHIBITION, OSLO.—The date for this Exhibition has been changed to October 5-17, 1954. Full details for exhibitors and visitors are now obtainable from the Exhibition Secretariat, at Munkedamsveien 53 B, Oslo, Norway.

DR. F. F. JARAY, consulting engineer, has opened a new office at 6 Sansome Place, Worcester (Telephone No. 5369). He is specializing in the design and development of chemical plant and corrosion-proof materials.

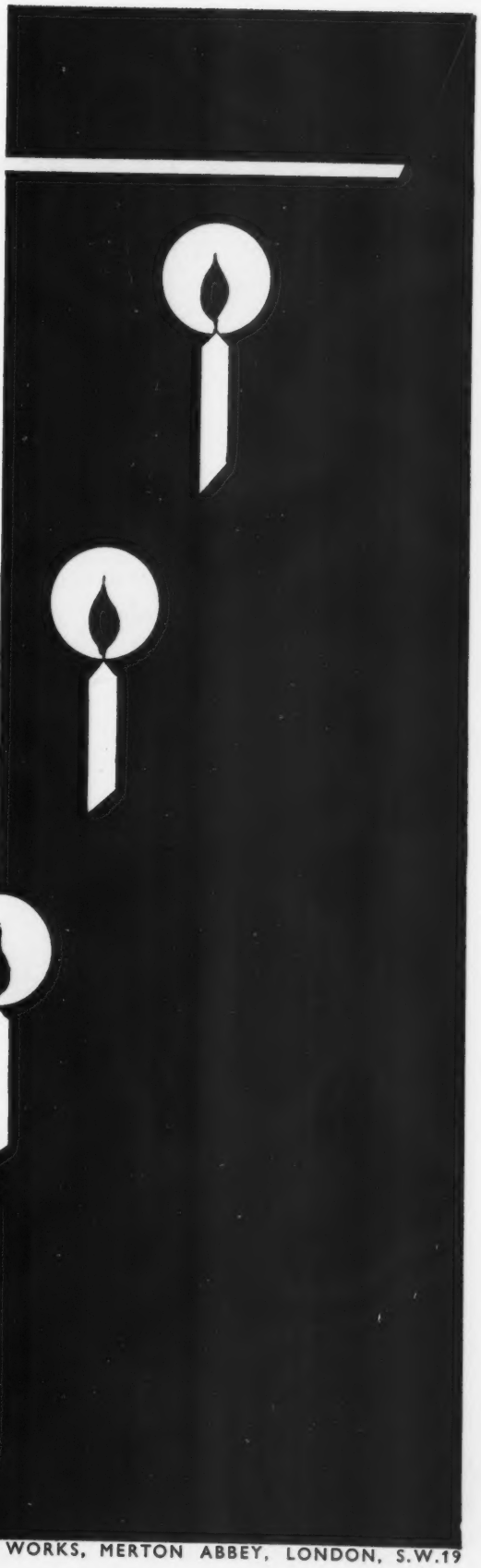
BRITISH PLASTICS FEDERATION INFORMATION SERVICE.—What is believed to be a unique service operated by a trade association on behalf of its members is reported on by the British Plastics Federation. Its information bureau, founded nine years ago to provide technical information on plastics, is now dealing with over 5,000 inquiries a year. The library includes almost all technical journals from all parts of the world dealing with plastics. As part of the information service 150 journals, also patents, are regularly abstracted. The abstracts are classified for reference and are also published and circulated by subscription to almost all countries of the world. Twelve monthly issues are published in two forms—printed on one side only, so that they can be pasted up into a form of card index, or printed on both sides. The charge is the same for each—10 guineas per annum, post free, from the Federation offices, 47 Piccadilly, London, W.1.



Christmas Greetings and Best Wishes for the New Year

from

James Ferguson and Sons Ltd



ADVT. OF JAMES FERGUSON & SONS LTD., LEA PARK WORKS, MERTON ABBEY, LONDON, S.W.19

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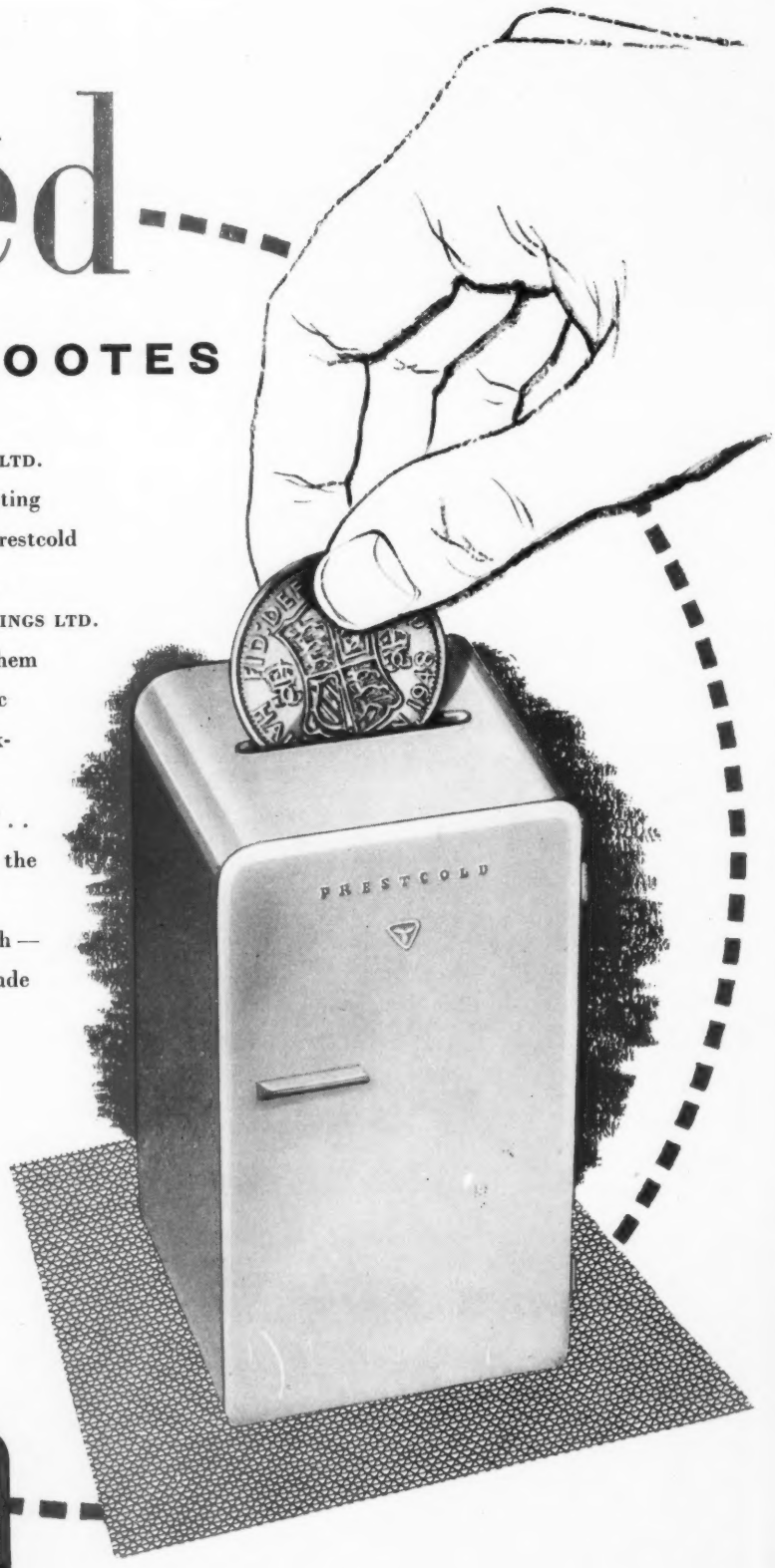
by ROOTES

Hats off to PRESSED STEEL CO. LTD. for the brilliant idea of distributing Money Boxes in the shape of Prestcold Refrigerators. Hats off, too, to the designers at ROOTES MOULDINGS LTD. who had the job of moulding them in white plastic. Because public demand proved greater than expected, production had to be stepped up almost 'over-night' . . no easy task. It was here that the policy of tackling the job all under one roof proved its worth — the tools were designed and made on the spot and production went ahead without delay.



If you've a moulding problem why not pass it to ROOTES? They can save you time and money as well!

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Contractors to M.O.S., *Admiralty, etc.* A.I.D. *approved*
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Smee's R104

Mr. and Mrs. E. K. Cole (centre), together with other Directors of E. K. Cole Ltd., welcomed members of the Worshipful Company of Horners, including Mr. R. B. Hilton, the Deputy Master, who visited the Southend works of E. K. Cole Ltd. recently. The Horners, one of the oldest of the City of London Guilds, made an extensive tour of the EKCO works.

DR. R. F. HUNTER, D.Sc., A.R.C.S., research manager of Bakelite, Ltd., gave a lecture entitled "The Structure of Phenoplasts" before a large audience at the Royal Technical College, Salford, on October 22. After a brief résumé of the subject, Dr. Hunter dealt with the rational synthetic work on unblocked resols and novolaks carried out in the research laboratories of Bakelite Ltd., and elsewhere, and the application of physical methods to the problem of structure of phenoplasts. The lecture concluded with a brief account of theories of hardening.

WICKMAN LIMITED announce the opening of a London branch office and factory in Cricklewood, London, N.W.2. The company's London area office which was previously at Stratton Street has also been transferred to the new address. A showroom is being installed in the new premises where machines of the company's manufacture will be displayed together with many machines of British and Continental manufacture for which the company are selling agents in the United Kingdom.

B.I.C.C. FURTHER EDUCATION SCHEME AWARDS.—Nearly 200 awards were made to employee-students of British Insulated Callender's Cables, Ltd., Further Education Scheme during a ceremony at the company's Prescot works, Lancs, on October 29, which was attended by approximately 650 people, including relatives and friends of the successful students. The awards were presented by Mr. D. W. Aldridge (director), deputizing for Mr. H. J. Stone (director and deputy chief executive), to students who had successfully taken courses at the B.I.C.C. Day Continuation School at Prescot, or at local technical colleges. The awards, including 30 Higher National Certificates, showed an increase of nearly 50 over the previous year.

POLYESTER RESIN PRICE REDUCTION.—Scott, Bader and Co., Ltd., have announced a price reduction which makes possible the sale of polyester resin at 3s. 2d. per pound on a contract basis. The company claims that this now brings polyester resins into the general field on a cost basis.

BAKELITE LIMITED have declared an interim dividend of 3% on the issued ordinary shares of the company. This is the same as 1952.

STANDARDS ORGANIZATION.—The third meeting of ISO/TC 61-Plastics, took place in Stockholm from August 10-14, 1953, when the following countries were represented:—Belgium, France, Germany, India, Italy, Netherlands, Sweden, Switzerland, United Kingdom, United States of America, Denmark (observer), Norway (observer).

The International Union of Pure and Applied Chemistry and the Fifth International Congress on Plastics also had observer representatives. The I.E.C. Committee on Insulating Materials, IEC/TC 15, had appointed an observer but he was unable to be present.

The chairman of the meeting was Dr. Kline, U.S.A., with Dr. Liander (Sweden) as co-chairman.

The United Kingdom delegation, nominated by the Plastics Industry Standards Committee of the British Standards Institution, were: Mr. G. Dring (Leader), Dr. H. M. Glass, Mr. H. W. Hall, Mr. R. Hayes, Mr. H. V. Potter, Mr. A. A. Tomkins, Mr. C. Wainwright, Mr. P. N. Welford, Dr. A. H. Willbourn. Mr. H. V. Potter was also an observer on behalf of the International Union of Pure and Applied Chemistry.

The ISO Committee is dealing with methods of test and nomenclature through the medium of six working groups.

The group on Physical Chemical Properties (Secretariat, United Kingdom), has reached the final stages of drafting a proposal on the water absorption of plastics which will now be sent to the American Standards Association, as Secretariat for ISO/TC 61, for circulation to all the member countries of the Committee. Preliminary agreement has also been reached on the determination of powder density and of acetone soluble matter. The group is now going to proceed with further work covering such items as:—

1. Methanol soluble matter of polystyrene.
2. Styrene (monomeric) content of polystyrene.
3. Determination of free phenol, free ammonia, chlorides and pH of water extract of phenolic plastics in the moulded form.
4. Water vapour permeability of plastics.
5. Boiling water absorption of plastics.
6. Specific viscosity of polymers in solution.

The working group on Thermal Properties (Secretariat, U.S.A.) has drafted a method of determining the temperature of deflection under load. This was discussed fully by the working group at the Stockholm meeting and, subject to certain amendments at the meeting, will, it is hoped, shortly go forward to the Secretariat of the main committee for circulation to all member countries. With regard to the future programme of work of this group it was agreed that attention should now be given to test methods for flammability. It was also agreed that the group should study the various methods of test now in current use for the determination of the flow properties of plastics.

The working group on Conditioning and Laboratory Atmospheres (Secretariat, Sweden) had a long discussion on how to define the needs of different areas such as America, Europe, and tropical countries. They arrived at the compromise that for conditioning prior to test, values of 22 ± 2° C. and 65 ± 5% should be adopted for temperature and relative humidity in temperate climates and that as a supplementary set of conditions for tropical and sub-tropical countries the corresponding values should be 27 ± 2° C. and 65 ± 5%. The matter was discussed in plenary session and it was decided that a recommendation would be made to ISO Council that a new committee should be set up to co-ordinate the requirements of temperature and relative humidity for conditioning of test specimens among the various related ISO Technical Committees.

The working group of Strength Properties (Secretariat, Netherlands) has drafted a method of determining flexural strength. A considerable amount of discussion is now in progress regarding the choice of thickness of the test specimen to be used in the determination of impact strength. Some of the member countries wish to specify a test specimen ½ in. thick as already standardized in many countries, but others wish to introduce a smaller test specimen 4 mm. thick. Future work will include methods of test for the determination of elastic modulus, tensile strength and creep properties.

The working group on Nomenclature (Secretariat, France) has adopted a list of 200 terms for which the equivalents in several languages are to be agreed. It is intended to maintain close liaison between the U.K. and the U.S.A. as regards those special cases where usage of English terms may be different in the two countries. The British Standard 1755 "Glossary of terms used in the Plastics Industry" has formed an excellent contribution towards this work and the definitions in the British Standard will be brought into consideration when the group moves to the next phase of its work dealing with definition.

The first meeting of a new working group on Resistance of Plastics to Chemical and Environmental Conditions (Secretariat, Italy), was held and a comprehensive programme of work agreed.

The offer of the International Electrotechnical Commission's Technical Committee No. 15—Insulating Materials, to send forward methods of test for electrical properties was accepted and it was agreed that ISO/TC 61 should ask for a liaison member to be appointed to IEC/TC 15.

MR. F. R. WATERMAN.—The directors of Wiggins, Teape and Alex Pirie (Sales), Ltd., announce with great regret that their London sales manager, Mr. F. R. Waterman, has found it necessary to relinquish this post for personal reasons. Mr. Waterman who joined Wiggins Teape in 1904 has been London manager for 25 years and, although no longer responsible for London sales, he will be available in an advisory capacity until his normal retirement in 1954. As from November 2, Mr. P. Gardner, who has been assistant to Mr. Waterman for several years, has been appointed as London sales manager.

INTERNATIONAL PLASTICS CONFERENCE.—Canada will be host to the Tenth Annual Technical Conference of the Society of Plastics Engineers at Toronto from January 27 to 29 next year. The theme of the Conference is "Plastics International" and one of the delegates from abroad will be Mr. A. Renfrew, director of the plastics division of Imperial Chemical Industries, Ltd., who will discuss world developments in plastics. Full details of the Conference are obtainable from the Secretary, Society of Plastics Engineers, Inc., Security Bank Building, Athens, Ohio, U.S.A.

UNPUBLISHED REPORTS. — *Tool Steels for Plastic Dies* is the title of a report prepared by the Office of Technical Service, Washington. Useful information is given on the conditions, heat treatment and durability of a number of tool steels used for dies for moulding plastics. Recommendations are made for specific applications and a short bibliography is included. Copies may be obtained by communicating with the technical information and documents unit of the D.S.I.R., Curzon Building, 15 Regent Street, London, S.W.1.

TOY FAIR.—The Fifth Annual Harrogate Gifts and Fancy Goods Fair will be held from February 1-5, 1954. Full details can be obtained from 19-25 Gutter Lane, London, E.C.2.

THE IDEAL HOMES EXHIBITION will be held at Olympia, London, from March 2-27, 1954.

EUROPE'S LARGEST OIL REFINERY having an annual crude capacity of nearly 10 million tons and built at a cost of £2 million, the new Pernis refinery in Holland has now come on to stream. The plant was designed by the Shell Oil Co., Ltd.

CHEMICAL CLUB.—The Annual General Meeting was held on October 20 with Mr. F. E. Warner elected president, Dr. E. H. T. Hoblyn, chairman, and Dr. V. E. Yarsley a new member of the committee.

F. J. EDWARDS LIMITED.—Available from the company's offices at 361 Euston Road, London, N.W.1, is a machine tool catalogue No. MT.853. This identifies machine tools available, which range from abrasive cutting machines to vices and wood working machinery. Of particular interest to the plastics industry will be the new developments in portable electric tools, tapping machines and various types of grinding machines.

CHANGE OF ADDRESS.—The Bristol office of British Insulated Callender's Cables, Ltd., has been moved to 7-9 Barton Street, Bristol. Telephone No. Bristol 23453 remains unchanged.

NEW MARKING MACHINE MANUAL.—Recently published by Funditor Ltd., 3 Woodbridge Street, London, E.C.1, is an attractively produced manual on marking machines. Including a comprehensive list of machines manufactured, detailed information is also supplied on methods of use. Copies are available free of charge from the company's offices.

Mr. C. H. Colton.

TRADE MISSION TO THE MIDDLE EAST.—As announced recently by Mr. Peter Thorneycroft, President of the Board of Trade, a trade mission is in the course of a Middle East tour. A member of the party is Mr. C. H. Colton, a director of British Celanese, Ltd.

PRESSURIZED SYSTEM FOR ELECTRICAL CONTROL.—A bulletin published by the General Electric Company, reference P/2053, describes a new pressurized system for electrical control in hazardous atmospheres. The system is described in some detail and is supplemented by diagrams and figures. Copies are obtainable from the company at Magnet House, Kingsway, London, W.C.2.

CENSUS OF PRODUCTION.—The Board of Trade report on the Census of Production for 1950, volume 2, covering chemicals and paints and varnishes, is now available from H.M. Stationery Office at York House, Kingsway, London, W.C.2.

AERO RESEARCH TECHNICAL NOTES.—On September 16, Dr. N. A. de Bruyne, gave a paper on structural adhesives for metal aircraft to the Fourth Anglo-American Aeronautical Conference held in London. A summary of this lecture by Dr. Bruyne, who is managing director of Aero Research Limited, has been published as Bulletin No. 130. The bulletin is well illustrated with photographs and diagrams and offers an important contribution to the literature on the bonding of metals to metals.

NEW BRITISH STANDARD BS.974: 1953 constitutes a revision of the original specification covering symbols for use on flow diagrams of chemical and petroleum plant. Copies can be obtained, price 3s. 6d., from the Institution Sales Branch at 2 Park Street, London, W.1.

"SAVE THE ABBEY" APPEAL FUND.—The Westminster Abbey Appeal Fund, whose objective is to make the Abbey secure for the future by raising £1,000,000 for much-needed repair and restoration, is still far short of its target. Some £500,000 has still to be found by the end of the year if the appeal is to succeed. A new drive to raise the balance is now being made and readers who may wish to make their contribution towards restoring the Abbey, which for 900 years has played a unique part in the history of the nation, should send their donations to the Dean of Westminster, Jerusalem Chamber, Westminster Abbey, London, S.W.1.

MEETINGS

December

12th.—"Some Aspects of Molecular Distillation," G. Burrows, A.M.I.Chem.E., Institution of Chemical Engineers, North Western Branch, Leeds.

12th.—"Mechanical Shaft Seals for the Chemical Industry," T. H. Wood, Institution of Chemical Engineers, Midlands Branch. The University, Edmund Street, Birmingham. 3 p.m.

14th.—"Relation between Chemical Constitution and Properties of Polymers," Dr. R. J. W. Reynolds (I.C.I. Ltd., Dyestuffs Division). Society of Chemical Industry, Plastics and Polymer Group, Chemical Lecture Theatre, The University, Leeds. Joint meeting with Yorkshire Section, P.I. invited. 7.0 p.m.

16th.—"Glass Making," Mr. Curran, Pilkington Brothers. Plastics Institute, North-Eastern Section, The Neville Hall, Newcastle upon Tyne. 7.0 p.m.

16th.—Lecture by Dr. F. N. Woodward, B.Sc., Ph.D., F.R.S.E., of Institute of Seaweed Research. Institution of Engineers and Shipbuilders in Scotland. 7.30 p.m.

18th.—Film Evening and Presentation of Diplomas. Plastics Institute, Midlands Section.

January

5th.—"Some Mechanical Handling Problems in the Chemical Industry," J. Johnston. Institution of Chemical Engineers, Geological Society, Burlington House, London, W.1. 5.30 p.m.

7th.—"Furan Resins," R. McDowall, B.Sc., and P. Lewis. Plastics Institute, Southern Section, Polygon Hotel, Southampton. 7.30 p.m.

13th.—"Textiles and the new Synthetic Fibres," B. P. Ridge, Ph.D., B.Sc., F.R.I.C., F.T.I. Plastics Institute, South Wales and Monmouthshire Section, Newport Technical College. 7.0 p.m.

13th.—"Finishing," member of the staff of Cannings, Ltd. Plastics Institute, Yorkshire Section, St. Mark's House, 186 Woodhouse Lane, Leeds, 2. 7.0 p.m.

TALKING SHOP . . .

Resin-coated Wind Tunnels. According to the *Manchester Evening News*, the Ashton-under-Lyne factory of Loyne, Ltd., has developed a method of coating wind tunnels with ethoxylene-type resins to stand up to wind-tunnel testing of jet aircraft engines. This company has just completed such a coating for a new supersonic wind tunnel for De Havillands. The resins were supplied by Mody's of Warrington. The resin, in liquid form, is sprayed five coats thick on to the interior surfaces of the tunnel. Then it is "baked" under an infra-red heater at a temperature of 600° F. It is polished by machine and has proved completely resistant to abrasion and chemical action. A member of the firm stated: "The surface is perfectly smooth, almost unscratchable, and resistant to both heat and chemical action. The latter point is important as hot gases from the blast of a jet engine would strip normal painted surfaces in a second."

* * *

Plastic Conveyor Roller. In view of the great interest being displayed in p.v.c.-coated conveyor belting for coal mines it is interesting to note a report that a fireproof plastic conveyor roller has also been developed for mining use. The roller has an outer envelope of glass fibre reinforced plastics. Each end has a moulded plastic cup housing a graphite-loaded plastic bearing and dust seal. The shaft is fitted with specially devised sleeves on which the bearings run. It is manufactured by White's Marine Enginering Co., Ltd., Hebburn-on-Tyne. It is considered to be attachable to any existing conveyor structure. The makers say that the price is comparable with that of a steel roller of similar size. Advantages include light weight, corrosion resistance and the fact that no lubrication is required. The non-corrosive properties have been used in the handling of uranium ore where sulphuric acid is employed in the process.

* * *

Centrifugal Fan. The *Financial Times* recently described an all-plastic centrifugal fan with a capacity of 250 to 300 cubic ft. per minute, manufactured by Turner and Brown, Ltd., Davenport Works. Davenport Street, Bolton. It is made entirely from rigid p.v.c.

* * *

Local Productivity Committees. The efforts of the British Council of Productivity, which has taken over the excellent work formerly carried out by the Anglo-American Council for Productivity, to organize Local Productivity Committees is beginning to bear fruit. It is intended that local Committees having representatives from all sides of industry who meet regularly to discuss methods of increasing production. Among 13 such committees which have been formed in the East and West region of Yorkshire is one for York at which Mr. H. Beaumont of Derwent Plastics, Ltd., is represented. It will be remembered that Mr. Beaumont was a member of the Productivity Team on Plastics Moulding which visited the U.S.A. last year.

A Book at Bathtime. At last someone seems to have caught on to the brilliant idea of making a complete book printed on plastics material. The particular example recently illustrated in the daily papers was obviously intended for baby in the bath but I am sure that a similarly printed copy of *The Times* would find favour with many fathers.

* * *

The Modern American Home. The well-known American magazine *McCall's* sponsored the exhibit of an "all-plastic" room at this year's New York Home Furnishings show. The room—combining a living, dining and terrace area—features over 100 plastics items.

The design of the room and selection of the furnishings was the work of Mary Davis Gillies, Housing and Homes Furnishing Editor. It is emphasized what great advantages can be obtained by using plastics intelligently in their right pace. *McCall's* is to be congratulated on this exhibit and on the publication of the small guide which they sell at 25 cents, "Plastics: everything a woman could ask for." This is a beautifully produced ABC, listing trade marks, general qualities and uses of the principal materials from acrylics (pronounced ack-*rill*-icks), the clear, glasslike, pretty ones . . . to polyethylene (polly-*ethel*-een) the light, squeezy one . . . and vinyls (*vine*-ills) beauty that can have its face washed. If publications of this type were more common (Halex produced a good one some years ago) there would be fewer resentments against plastics for failing to do their job.

* * *

Building. Whilst on the subject of homes, I am glad to see more plastics manufacturers at the Building Exhibition. Ashdowns, Ltd., Cascelloid, Ltd., and Durasteel, Ltd., are all showing corrugated glass reinforced roofing. Aero Research, Ltd., have a new type of flooring material, Ardux tiles consisting of a hardwood veneer laminated to a resin-bonded sand base. It is claimed to combine the decorative appearance of wood with the dimensional stability and low cost of synthetic materials. The tile is laid in cement mortar direct into concrete; it is specially suitable for use in conjunction with sub-floor heating.

The commercial success of decorative laminates has attracted some newcomers to the field. Besides Holoplast, Ltd., and Warerite, Ltd., there is now Berite, a decorative plastic-surfaced board ⅛-in. and ¼-in. thick shown by J. Berry and Sons, Ltd., of Leytonstone. As it is somewhat cheaper than the thinner plastic veneers it is presumably not of the high-pressure laminate types. A stoved melamine-resin-surfaced hard board is shown by Panelwood, Ltd., Aycliffe, Co. Durham. Extrusion interest is only supplied by I.C.I. who show Alkathene tubing for cold water services and Alkathene acid-proof foil membranes for sub-floors of chemical works.

Searching for News. Last month under the same heading, I described the valuable work of the Technical Information and Documents Service of the Department of Scientific and Industrial Research. This month, on page 440, there is a note on the work of the Information Bureau and Abstract Service of The British Plastics Federation. Much of the credit for this excellent service should go to Dr. Farmer, the Librarian of the Federation, not only for the hard work that goes into the abstracts but for the helpful way in which she deals with inquiries.

* * *

Quiet Drive. At the London Motor Show we saw plastics sports cars, at the British Plastics Exhibition there was a complete bus front and now we hear that a lorry (that's a truck in American) shown at the Scottish Motor Show has an all-plastic driver's cabin, presumably in glass-reinforced plastics. In addition to the usual advantages of lower tooling cost, resistance to wear and corrosion, anyone who has taken a cross-country ride in a "ten-tonner" will appreciate the important advantage of a material that will reduce noise.

* * *

Printed Plastic Coats. Following my note on the increasing popularity of men's p.v.c. coats I am glad to report a news item which appeared in a recent copy of *Men's Wear* stating that Servitor Textiles, Ltd., have introduced a range of printed coats having a "fabric" appearance. What is even more interesting is that Mr. Leonard Cohen, the managing director, is expected to make an announcement about plastic coats that "breathe" within a few weeks.

* * *

Plastics Dummy Bullets. The British army, according to the *Press and Journal*, Aberdeen, is to experiment with dummy ammunition made of plastics. The ammunition has been developed by a Norwegian company and trial quantities have also been made for the Norwegian army and for France, Belgium and Switzerland.

* * *

New Venture for Catalin. The last financial report of Catalin, Ltd., stated that the company had acquired a controlling interest in Europlex. It is understood that this subsidiary will carry out h.f. welding of p.v.c. goods.

* * *

Cable Makers: Correction. With regard to the note about the formation of a Plastics Cable Makers Association, we are informed by Rists' Wires and Cables, Ltd., that they are not members of this association, as was inferred.

* * *

Nine miles of plastics oil line—First cross-country pipe line made entirely of extruded cellulose acetate butyrate is now operating from Williston Basin to a shipping point nine miles away. The 3-in. bore is designed to deliver 2,500 barrels of crude oil per day and takes 90 p.s.i. pressure. The smooth surface means that 40% more oil can be delivered with the same pump load compared with steel pipe.

PLASTIKON.

Opening of the National College of Rubber Technology

The new building at Holloway Road, London, was opened on November 3 by Lord Baillieu in the presence of the governing body and distinguished visitors following a celebration luncheon at the Trocadero Restaurant, London

THE National College of Rubber Technology was formed in 1938 as one of the first steps in implementing a recommendation of the Percy Report on higher technological education. The main object of the college is to provide highly qualified technologists who, it is hoped, will rapidly attain executive positions throughout the country.

The new building, work on which was started two years ago, is adjacent to and connected with the Northern Polytechnic, a happy arrangement in that it was in 1911 that courses in rubber technology were first offered at the Northern Polytechnic. Dr. Drakeley, now director of the National College, joined the Polytechnic in 1919, and the success of these classes in rubber technology was very largely due to his interest and activity.

Further advantage results from the connection between the Northern Polytechnic and the college; as a recognized training department of the University of London, the Northern Polytechnic can offer unique advantages to students of the National College. Their studies in physics and chemistry are followed in the Northern Polytechnic and they have also the advantages of the Polytechnic's library, refectory, and the communal student life of the Polytechnic as a whole.

The new building is undoubtedly one of the most modern centres for technical education in Europe and is equipped with an abundance of apparatus and machinery. The visitors to the college on its opening day could not fail to have been impressed both by the care which has been taken in the construction of the building and the thought which has been put into the planning of laboratory design for modern teaching and research.

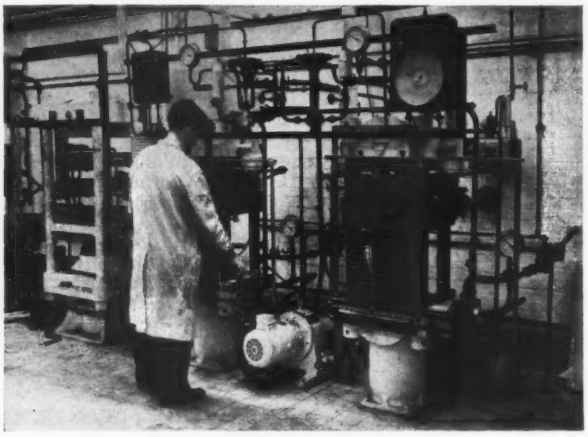
Of particular interest to the plastics industry is the polymer chemistry laboratory, the basis for full-time and part-time courses in plastics to both City and Guilds and A.P.I. level.

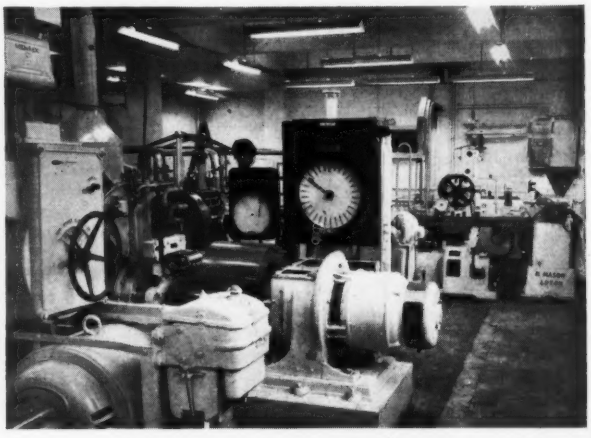
The Rt. Hon. Lord Baillieu, K.B.E., C.M.G., formally opened the college in the presence of Lord Waverley, Mr. H. Rogers, chairman of the Board of Governors, Dr. Drakeley, director of the college, and Dr. Cotton, head of the college.

In the course of his address, Lord Baillieu stressed the importance of technological education, in synthetics and rubber, to Britain's position as one of the foremost industrial countries of the world. His hope that the college is successful in its work should be justified in that it possesses unique facilities for higher education and is well endowed by industry.

The building was constructed at a cost of nearly £200,000, provided by the Ministry of Education. The future of the college will obviously depend upon the enthusiasm of industry, which should manifest itself not merely in the provision of money, but in the stimulation of research and the absorption of the trained technicians.

Lord Baillieu, having received the key from the architect, opens the main doors.



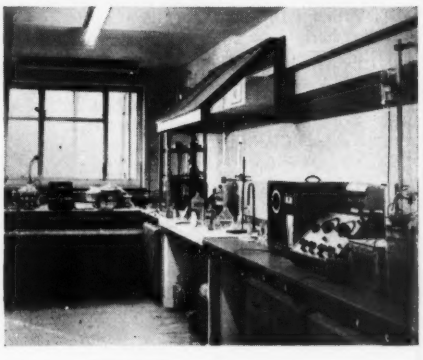


(Above, left) Two presses used by plastics students of the college.

(Above, right) Main workshop. On the right can be seen a Mason plastics extruder, a demonstration of which was internally televised on the opening day. The college is the first centre for technical education to be equipped with internal television.

(Left) Mr. Scott (architect), Lord Baillieu, Lord Waverley and Dr. Cotton (Head of the College).

(Right) High polymer research laboratory.



COPOLYMERS

Part II

The Formulation of Thermoplastic Materials by Copolymerization

By A. E. LEVER, A.I.R.I.

A review of some important materials capable of copolymerization, with extensive technical literature and patent references.

In the first part of this review which was published on pages 395-397 of the November issue of "Plastics," the author defined the term "copolymerization," and divided the field of materials as follows: 1. Butadiene, 2. Vinyl chloride, 3. Styrene, 4. Acrylonitrile, 5. Drying Oils, 6. Polyesters, 7. Acrylic esters, 8. Isobutylene, 9. Miscellaneous. The author then went on to deal briefly with each of these main groups and this, the second and final part of the review, commences with the sundry copolymers of vinyl chloride. For the convenience of the reader, the literature references at the end of the article include those which were published last month.

2. Vinyl Chloride (continued)

(b) Sundry copolymers

Vinyl chloride may be copolymerized with styrene[1] provided the proportions of the two monomers are carefully controlled (1-10% styrene) and a special redox catalyst is used. The resulting copolymers are soluble in cheap solvents, stable to light, heat, etc., and may be cast or moulded without plasticizer to form a clear and translucent product. Dow Latex 744-B is a vinyl chloride-vinylidene copolymer suggested for water paints, but it needs some modification to produce coherent films.

Geon 200 series[1] are copolymers of vinyl chloride-vinylidene chloride:—

Table 4

	Vinylidenechloride	Soluble in Methyl ethyl ketone	Diocrylphthalate. Shore hardness 85
	Approx. %	%	
202	6	8	46
203	12	14	44
204	15	15	42
205	20	17.5	35

Another series produced in Germany are the vinylchloride-maleic and fumeric ester copolymers:—

Mipolam ..	Vinyl chloride 80	methyl acrylate 20
Luvinal M20 ..	„ 80	dimethyl maleate 20
Igelite MP-A ..	„ 20	dimethyl maleate 10
		diethyl maleate 10
	(used for rigid sheeting)	

A vinyl chloride-diethyl maleic copolymer is disclosed.[1, 39]

Vinyon N, a vinyl chloride-acrylonitrile copolymer, is claimed to give improved solvent resistance, better dye affinity, higher softening point, non-inflammability and higher strength. It contains 56-60% vinylchloride. It can be compression moulded, but in common with resins containing large amounts of acrylonitrile, its flow characteristics are poor compared with the vinyl chloride-acetate resins. Copolymers in the range of composition preferred for fibres show only slight solubility in methyl ethyl ketone.

3. Styrene

In this section those copolymers in which the styrene fraction predominates are discussed. Many of them are known as "high styrene" resins and are finding important uses for footwear.

The following are some of these type resins now being offered, under their trade names.[40]

Table 5

Trade name	Supplier
Butaprene SL and SD	Firestone Tire and Rubber Co.
Darex	Dewey and Almey Chemical Co.
Goodrite 50	B.F. Goodrich Chemical Co.
Hycar 2007	British Geon Ltd.
Kralac	Naugatack Chemical Division, U.S. Rubber Co.
Marbon S and S1	Marbon Corporation.
Pliolite S3 and S6	Goodyear Tire and Rubber Co.
Latex 512K (60% styrene)	Dow Chemical Co.
Polysar SS250 .. .. 40% high styrene resin+ 60% GR-S	Polymer Corporation.

Details are given[41] on styrene monomer reactivities found by copolymerizing various pairs of monomers.

Studies of the thermal decomposition of various copolymers have shown that in many cases the yields of monomer are much lower than would be expected from the number of monomer units known to be in the copolymer, and the behaviour of the simple polymer, e.g. the yields of styrene from styrene-butadiene copolymers, are much less than the corresponding yield of styrene from polystyrene. There is an exhaustive survey of the patent literature on styrene copolymers with appropriate references in[41].

Grassie,[42] while not dealing specifically with copolymers, gives an interesting discussion on depolymerization reactions in vinyl polymers and notes that polymethyl methacrylate is one of the few synthetic polymers to yield practically 100% monomer on heating.

Hycar 2007[43] is a high-styrene resin (approximately 85% styrene), and the following points are of interest: (a) The modulus of natural rubber —2007 blend increases more rapidly than in a corresponding system based on GR-S. (b) The ultimate tensile strength of both types of blend is the same for the same resin content. (c) Abrasion resistance of a natural rubber blend is initially higher, but falls more rapidly with added 2007 than does GR-S. (d) Low-temperature flexibility and resistance to continued flexing are not materially affected with increasing resin content. (e) Hycar 2007 is more effective as a processing aid in natural rubber compounds than in GR-S compounds. (f) Improved individual properties may be obtained by varying the milling temperatures.

Table 6

	Roll temperature
	°F.
Highest tensile	125
Highest elongation	200
Highest tear, hardness and abrasion	250

Aiken[44, 45] gives details of the formulation and processing of Pliolite high-styrene resins, and *inter alia* makes the following observations: (a) S.3 and S.6 added to natural rubber compounds reduce the curing time. (b) Improved impact strength is obtained. (c) Compounds have a heat-distortion point of the resin used (130-140° F.) and a brittle point of the rubber used; within 10-30% rubber, these two properties are independent of the amount of rubber used. (d) These resins

are only slightly unsaturated but can be vulcanized in the conventional manner. (e) For compression moulding, preheat the stock for 10-15 min. at 305° F. (f) Articles must be cooled immediately on removal from the mould. (g) The stiffness is high and varies according to the resin/rubber ratio.

Another grade, Pliolite S.6c,[46, p.334] is offered for heat-resistant applications.

The stiffening effect that can be obtained when using high-styrene resins in soft rubber compounds has been applied to hard rubber compounds.[47, 91] It is possible to produce compounds of high hardness with a lower sulphur content, and in some cases with improved impact strength. In the study to which reference is made, GR-S was the basic polymer used. Apart from the physical improvements, in the sense of tensile and impact strength, there was noticeable improvement in appearance.

A high-styrene copolymer is used[46, p.336] for the production of pails for use in the chemical industry. They are resistant to most corrosive solutions and have a high strength combined with light weight. Copolymer 348 is suggested as a useful addition to polystyrene to improve impact strength. It is a copolymer of 70% styrene and 30% butadiene.

An interesting use for Kralastic, a styrene-acrylonitrile copolymer, is for wheels on a power-driven lawn mower.[49] In temperature tests, the moulded parts were heated to 220° F. and cooled to −16° F., and the wheels did not crack or warp.

Styrene and vinyl acetate will not copolymerize; the acetate remains unchanged.[50] Styrene and divinylbenzene yield an insoluble polymer.[51] Styrene, with a small percentage of certain monomers, gives better heat resistance and impact strength, e.g. acrylonitrile, dichlorostyrene, N-vinyl-carbazole, etc.[1] (see also [52] for data regarding heat-resisting polystyrene).

Ion exchange resins, e.g. Dowax (Dow Chemical Co.) are described in [53, 54, 55, 56].

Other copolymers of interest are: Trolitul EN (I.G. Farb.), 70% styrene, 30% acrylonitrile. Trilitul EH, 50% styrene, 25% acrylonitrile, 25% carbazole. Styron 671 (Dow), described as a heat-resisting copolymer. Cerex 250 (Monsanto), also a heat-resisting copolymer. Plexene M and C.11, a styrene-acrylonitrile copolymer. Bakelite C.11, a styrene-acrylonitrile copolymer.

4. Acrylonitrile

Acrylonitrile-vinylidene chloride copolymers are referred to by Calsibet,[3, p.627] and he lists several grades of Saran F120 varying in viscosity from 40 to 8,000 cps., useful as surface coatings. Some of the earlier difficulties connected with extrusion and injection moulding of polyvinylidene have been overcome by modification of the polymer. One such copolymer is said to contain 10% vinyl chloride.[57, p.279]

5. Drying Oils

Oils, such as dehydrated castor oil fatty acids, may be copolymerized with styrene, and this reacted with a polyester to form a product which has wide application for industrial finishes.[58] A new type of surface-coating material has become of increasing importance and made by reacting vinyl-type monomers with drying oils and their derivatives. The term "copolymerized" has been applied to cover these materials irrespective of the type of reaction that takes place between the monomeric material, the oil and the resin. About the only requirement for a resin-monomer combination to be called a copolymer is "that the products show some degree of solution and film clarity."[3, p.611] When properly reacted into oils or alkyds, the styrene imparts the desirable properties of styrene, such as hardness, gloss, chemical resistance, etc.

Bevan[59] reviews the progress made up to 1949 in the manufacture of styrene copolymers for surface coating, and in particular gives a list of the various master patents held in this field by I.C.I. Ltd., Lewis Berger and Sons, and Dow Chemical Co.

Bosch and Drubel[16] describe work on the styrination of tall oil. Armitage and Kut[60] have reported on their work on the course of the reaction in styrene copolymers. There is a good bibliography.

Parker[3, p.620] gives some practical hints on the use of styrene-butadiene latices in emulsion paints.

6. Polyesters

Polyester-styrene resins are made by copolymerizing with preformed unsaturated polyester or glyptal of a viscous liquid character.[61] Chemigum. S.L.[62] is an elastomeric polyester-urethane made by the condensation polymerization of a low molecular weight polyester adipate with diisocyanate. Of M.W.20-50000. It is compatible with natural rubber, GR-S, and Neoprene. It is recommended for tyres, soles and flooring. Paraplex P. are cured polyester-styrene resins which do not soften readily on heating and do not dissolve in solvents, but may swell in ketones and chlorinated hydrocarbons.

Marco Resin 100 parts—20 parts styrene monomer with 2 parts of catalyst[63] are not strictly copolymers but have been included as of some interest in this connection. There are numerous references to copolymerizing styrene with preformed unsaturated polyesters.[64]

Polyester-styrene casting resins[1]: Paraplex P., Permafil, Vibrin, Fostente, Laminac, Genpol, Thalid X.

7. Acrylic Esters

Hycar PA21, a copolymer of an acrylic acid ester and a halogen containing derivative,[65, 66] gives vulcanizates with good resistance to heat, light, hot oils, greases and low permeability to gases. It is compounded in a similar manner to conventional rubber but selective pigmentation is essential, due to the fact that the vulcanization depends largely on the maintenance of a basic pH in the uncured stock.

It would appear that medium abrasion-resistant and reinforcing blacks are useful for general purpose stocks, but compounds containing these blacks tend to lose tensile strength on prolonged heat ageing. Compounds reinforced with semi-reinforcing blacks, while not having such a high initial tensile strength, show little change after ageing. Slight reinforcement is obtained with calcium silicate or hydrated silica but, in general, white fillers have little reinforcing value. The use of plasticizers is generally unnecessary. Mast and Fisher[67] have examined the effect of a number of plasticizers in polyacrylic rubbers.

Acronal 500D is a butyl-acrylate and vinyl acetate copolymer. Lactoprene E.V. is a product with 95% ethyl acrylate and 5% 2.chloroethyl vinyl ether. Polysize 177, 179, 200 are acrylic ester copolymers offered by the American Polymer Corporation in emulsion form.

8. Isobutylene

First described by Thomas and others,[68] butyl rubber is a copolymer of an olefin with a small percentage of diolefin e, gisobuylenen and isoprene. Further work is reported by Haworth and Baldwin.[69] Adams and Buckler[70] review the evolution and application of butyl rubber to 1952. There are four principal types: Butyl 100, 200, 300, 400, in order of their decreasing unsaturation.[71] The longer vulcanization times required for Butyl 100 causes Butyl 300 to be preferred. Black fillers give better properties than white fillers, and furnace blacks are to be preferred to channel blacks.

It is being used for inner tubes, curing bags, mechanicals, cables, and finding an important use for protective proofing owing to its extreme impenetrability to gases. It is not considered suitable for tyre treads. Differences in milling conditions cause significant variations in the dispersion of semi-reinforcing black in butyl rubber,[72] and the subject is further pursued by Ford and Gessler.[73]

The modulus of butyl rubber vulcanizates is lower than that of natural rubber vulcanizates[74] and also less rigid.

Carbon black does not increase tensile strength to the same extent as in GR-S. It has greater resistance to flexing and its impermeability to gases is outstanding compared to all other synthetic rubbers.

9. Miscellaneous

(a) Styrene modified chloroprene

Neoprene R.T. with 40 parts chloroprene and 10 parts styrene has been developed so as to give better retention of building tack than other grades of chloroprene rubbers.[1, 75] It has improved flexibility and increased resistance to hardening due to elastomer crystallization. Neoprene WRT[76] is also offered with improved processing characteristics, more like natural rubber.

(b) Silicone

Silicone rubbers have been prepared[77] from copolymers of dimethylsiloxane and diphenylsiloxane, to which is added an organic peroxide and various fillers. Tetra allyl silicate may be copolymerized with methyl methacrylate to produce modified polymers with increased toughness compared with normal polymethyl methacrylate.[78]

(c) Vinylidene chloride-vinylchloride

Details are given[79] of a copolymer suitable for fabrics, fishing nets, carpets (blends with wool), as well as rigid tubes. It will withstand temperatures up to 60° C. and a typical type has a softening point of 115-130° C. It is self-extinguishing with low water absorption (<0.1).

(d) Methyl Methacrylate

Some results have been reported on the effect of varying ratios of methyl methacrylate to butadiene when copolymerized.[50, 80]

(e) General

Royalite[82] is a compound of butadiene-acrylonitrile copolymer and an acrylonitrile-styrene copolymer. The ratio may be varied to produce a series of compounds suitable for mouldings such as typewriter cases, helmets, trays, etc. It is particularly suitable where high impact strength is of importance and is described as a plastic which is "both decorative and functional."

Recently fatty-acid esters of Epikote resins (reaction products of bisphenol and epichlorhydrin) have been styrinated in solution with styrene and with mixtures of styrene and a-methyl styrene.[3]

Methyl methacrylate-sodium methacrylate copolymers[83] have been offered as emulsifying, dispersing, stabilizing and thickening agents. They combine the features of an anionic emulsifying agent and that of a colloid.

Zwicker[85] gives an interesting list of synthetic lattices, including many copolymers, with appropriate references.

An interesting patent[86] discloses the use of certain resins and copolymers to reduce the occurrence of scorching. In effect, it is to coat the sulphur particles with resin, e.g. vinyl chloride-acetate copolymer, etc.

The prevention of shrinkage of wool is claimed for copolymers of butadiene-chloroprene[87] and chloroprene with vinyl compounds, such as methyl, ethyl or butyl acrylate, styrene, dimethyl styrene, etc.[88]

References

The following abbreviations are used for journal titles in the list of references: *I.R.W., India Rubber World; Trans. I.R.I., Transactions of the Institution of the Rubber Industry; Ind. and Eng. Chem., Industrial and Engineering Chemistry; Off. Digest, Official Digest of the Federation of Paint and Varnish Clubs; Rubber Chem. and Tech., Rubber Chemistry and Technology: R.A. (N.Y.), Rubber Age, New York. Mod. Plast., Modern Plastics; Chem. and Ind., Chemistry and Industry; J.O.C.C.A., Journal of Oil and Colour Chemists Association; Abs. Rub. Chem. Div. A.C.S., Abstracts of the Rubber Chemistry Division of American Chemical Society; Br. Plast., British Plastics; R.A.B.R.M. Abstracts, Research Association of British Rubber Manufacturers Abstracts; Rev. Gen. Caout., Revue Generale du Caoutchouc; Trans. Fara. Soc., Transactions of the Faraday Society.*

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PATENT REVIEW

The following abstracts have been made from specifications at the Patent Office, with the permission of the Controller of H.M. Stationery Office. The country of origin for Convention Applications is shown in parentheses. Complete specifications can be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, price 2s. 8d. each (including postage).

B.P. 695,217. Moulds for making welded joints of thermoplastic material. B. F. Thorne. To: Telegraph Construction and Maintenance Co. Ltd.

The joint refers to polythene sheathed cables. Two mating brass halves enclose an annular space around the overlapping ends of the thermoplastic parts. This space is filled by injection with thermoplastic material, the inner mould element being rotatable within the housing for varying the point of entry of heating fluid into the mould.

B.P. 695,224. Construction of model railway track. C. R. Wrenn.

B.P. 695,247. Spectacle-frames. M. J. van de Laar, T. T. van der Vliet (Netherlands).

A metal rod inserted in bores in the plastic lens rims forms nose bridge and ear hooks.

B.P. 695,276. Synthetic resin moulding compositions. To: Deutsche Gold und Silber-Scheideanstalt (Germany).

Moulded bodies of synthetic resins and including up to 50% (by weight) of natural or synthetic rubber have incorporated finely divided oxides produced by thermal decomposition of metals or metalloids. The articles show particular hardness and impact resistance as required for teeth, protheses, dental aids, packing rings, elastic rollers, convevor bands, surgical gloves.

B.P. 695,289. Airtight container. G. Trill.

The container may be a tobacco pouch, powder box or the like.

B.P. 695,312. Rolls for calenders or like machines. W. C. Whittum. To: Farrel-Birmingham Co. Inc. (U.S.A.).

The rolls are provided with a camber to compensate for the bowing of the central portion of the rolls under heavy pressure with a modification towards the ends to compensate for differences in thermal expansion. Thus a uniform thickness of, e.g., sheets of plastics passing through the calender is obtained.

B.P. 695,344. Continuous method for cooling and shaping thermoplastics. G. E. Stober. To: Dow Chemical Co.

Polystyrene is fed to the outer surface of a grooved drum and repeatedly pressed against this surface during a single revolution. At the same time, a cooling fluid is passed through the drum. Portions of the shaped resin sheets delivered from the drum are successively severed and the rod portions separated.

B.P. 695,363. Viewing instruments. F. Smith.

Use of a rigid transparent (plastic) tube surrounding a rolled-up display film to be viewed through the tube.

B.P. 695,369. Equipment for use by colostomy patients. A. J. Churcher.

A flexible envelope of "Cellophane" or "Pliofilm" is suggested to be placed against the patient's body.

B.P. 695,396. Weather indicator. W. H. Haughton.

The toy house may be made of plastics.

B.P. 695,403. Closure for containers. F. Heinemann (Germany).

The hood (for tubes, bottles) is formed of elastic polymerizates and mixed polymerizates of styrene, vinyl and acryl compounds and unsaturated hydrocarbons.

B.P. 695,428. Nozzle on injection moulding machines for thermoplastic material. To: Maschinenfabrik and Giesserei Netstal A.G (Switzerland).

To obtain a high rate of heat transmission and to reduce the resistance to the passing of the material, a heatable cylinder is mounted in the head with a liquefier insert divided in an axial plane and subdivided by longitudinal fins into a plurality of longitudinal passages.

B.P. 695,439. Electric plug and socket connector. A. G. Haslam. To: Belling and Lee Ltd.

For very high radio frequency, polyethylene is the only insulating material possessing the necessary resilience and operating with a reasonably small loss. To prevent melting when soldering conductors, the insulator is formed in a plurality of parts interconnected by flexible strands allowing considerable opening of the insulator parts.

B.P. 695,449. Acrylonitrile copolymers. To: American Cyanamid Co. (U.S.A.).

The mixture consists essentially of acrylonitrile (85 to 93 parts) and allyl alcohol and/or methallyl alcohol (15 to 7 parts). The molecularly oriented fibres may be used for light- and weather-resistant textiles for filter cloths, bristles, rattanlike fabrics, floor mattings.

B.P. 695,457. Poly-siloxane resins. To: Diamond Alkali Co. (U.S.A.).

Resins in the production of which organotrihalosilanes are employed as starting substances are rapidly convertible to hard, tough, tenacious heat-resisting, moulding resins incorporating mineral fillers.

B.P. 695,462. Thienyl-substituted polysiloxanes. To: British Thomson-Houston Co. Ltd. (U.S.A.).

B.P. 695,500. Light reflector. E. L. Jonas.

B.P. 695,508. Bags, boxes, cases or the like. G. Reitzel (Germany).

The strengthening frame with protruding tongues may be formed, i.e. from plastic material.

B.P. 695,521. Process for the preparation of rubber and plastic materials of cellular structure. To: Farbenfabriken Bayer (Germany).

A mixture of oxalic acid (or salt of) and an amidine compound is employed as heat decomposable substance.

B.P. 695,524. Method of insulating sector conductors of electric cables. To: Tréfileries et Laminoirs du Hâvre (France).

A heated plastic is extruded under pressure to form a continuous sheath having a coefficient of expansion greater than that of the conductor material so as to contract and thus adhere very tightly around the conductor.

B.P. 695,552. Phenol-aldehyde resin compositions. W. E. A. Simon. To: Brycel Ltd.

For prevention of corrosion of ferrous metals a composition is recommended of ortho-cresol Novolac resin, methanol, ferric chloride, ammonia water, tricresyl phosphate.

B.P. 695,567. Super-stretching polyester filaments, yarns, films and similar structures. To: E. I. du Pont de Nemours and Co. (U.S.A.).

The products are formed of polymethylene terephtalate, then stretched up to 75x the original dimensions (at 20 to 60° C.) in one dimension, and oriented by drawing.

B.P. 695,581. Coating compositions having a plastic base. W. F. Flanagen. To: New Wrinkle Inc.

The composition comprises vinyl chloride-vinyl acetate copolymer (150), butyl acetate (100), methyl ethyl Ketone (100), cyclohexanone (125 parts).

B.P. 695,598. Process for manufacturing coloured figured thermoplastic materials. N. Boeckle. To: Lonza Elektrizitaetswerke und Chemische Fabriken A.G. (Germany).

The process relates to fancy coloured figures of polyvinylchloride or a copolymer of it. A first monochromatic dyeing is combined with a short heat treatment which is interrupted, and the product then crushed and mixed with material of other colour.

B.P. 695,608. Dripless spouts or lips for containers. E. S. Lilly. To: C. W. Freed (U.S.A.).

An asymmetric lip projects from the upper rim.

B.P. 695,611. Method and apparatus for moulding hollow articles from thermoplastic materials. R. Colombo (Italy).

The ends of a segment of a tubular blank are clamped, a hollow needle is inserted in the axis of the segment and pressure fluid introduced causing the blank to take the shape of the mould.

B.P. 695,625. Resinous materials. British United Shoe Machinery Co. Ltd. Comm. from: United Shoe Machinery Corp.

The material comprises a mixture of polyvinyl chloride and butadiene-acrylonitrile copolymer rubber. The material is softened and the granules caused to expand under the action of a blowing agent and to coalesce to a cellular structure. The material is then cured.

B.P. 695,630. Teaching equipment. E. J. Foster.

A transparent sheet with apertures or notches and instructions printed thereon.

B.P. 695,633. Polymers, including copolymers, from new esters of acrylic or methacrylic acid. E. Ellery, S. L. M. Todd. To: I.C.I. Ltd.

B.P. 695,648. Frame members for screens. M. Kilemnik.

Light-transmitting moulded plastic members of the same cross-section compose the frame.

B.P. 695,686. Construction of toy motor vehicle bodies. G. M. Mejlso, E. S. Heimann.

B.P. 695,690. Screw cap for metal containers. P. Jones. To: Kork-N-Seal Ltd.

The cap of phenol-formaldehyde or urea-formaldehyde resin is provided with a knife-edge ridge indenting the neck face instead of using a sealing disc.

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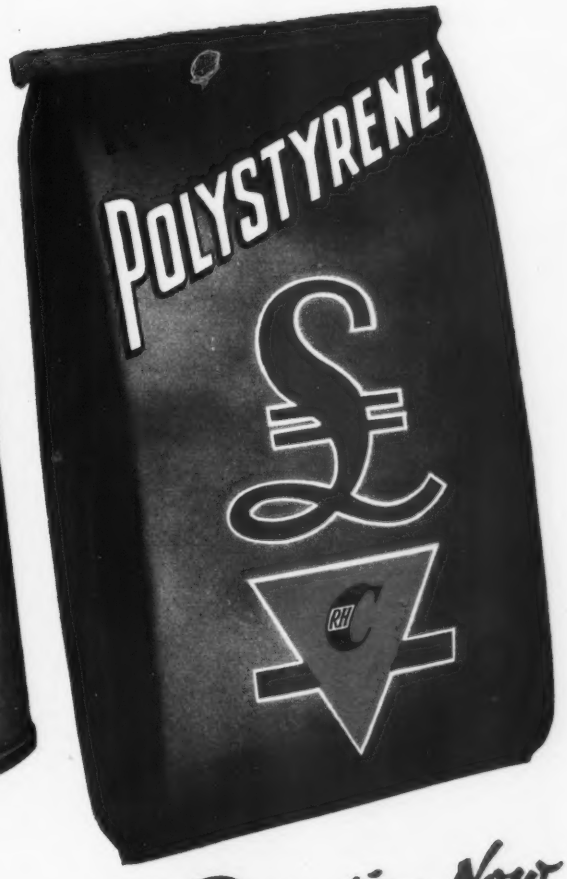

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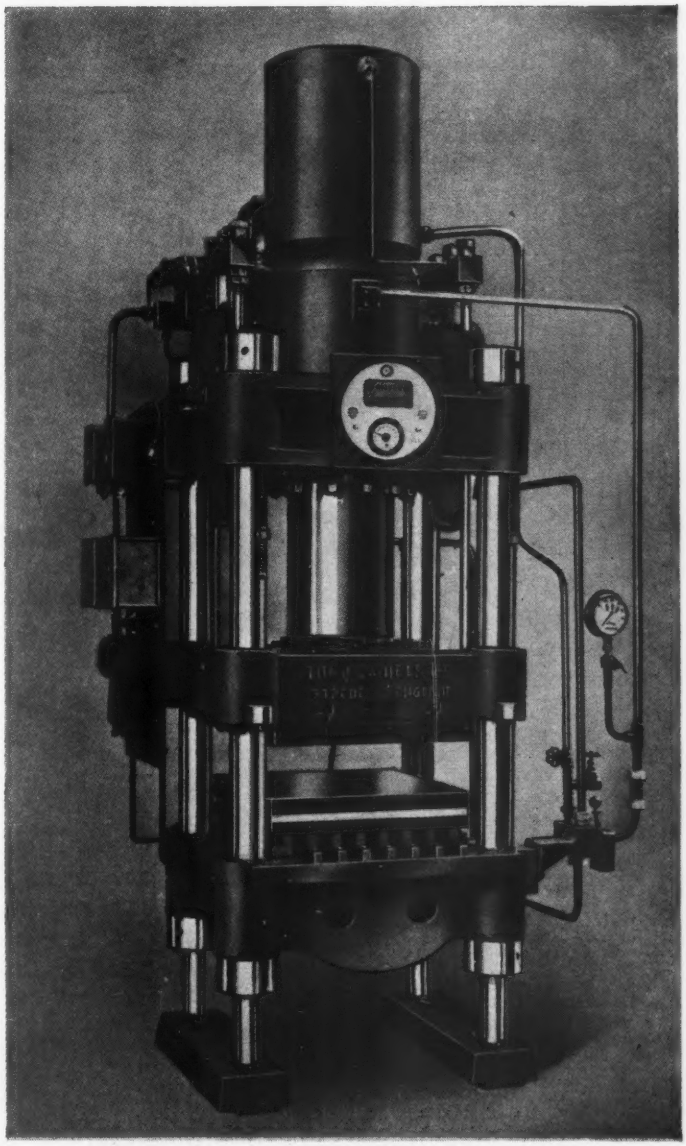

Photograph by courtesy of Messrs. T. H. & J. Daniels, Ltd., Stroud, Glos. The Press is fitted with the Daniels Automatic Process Timer.

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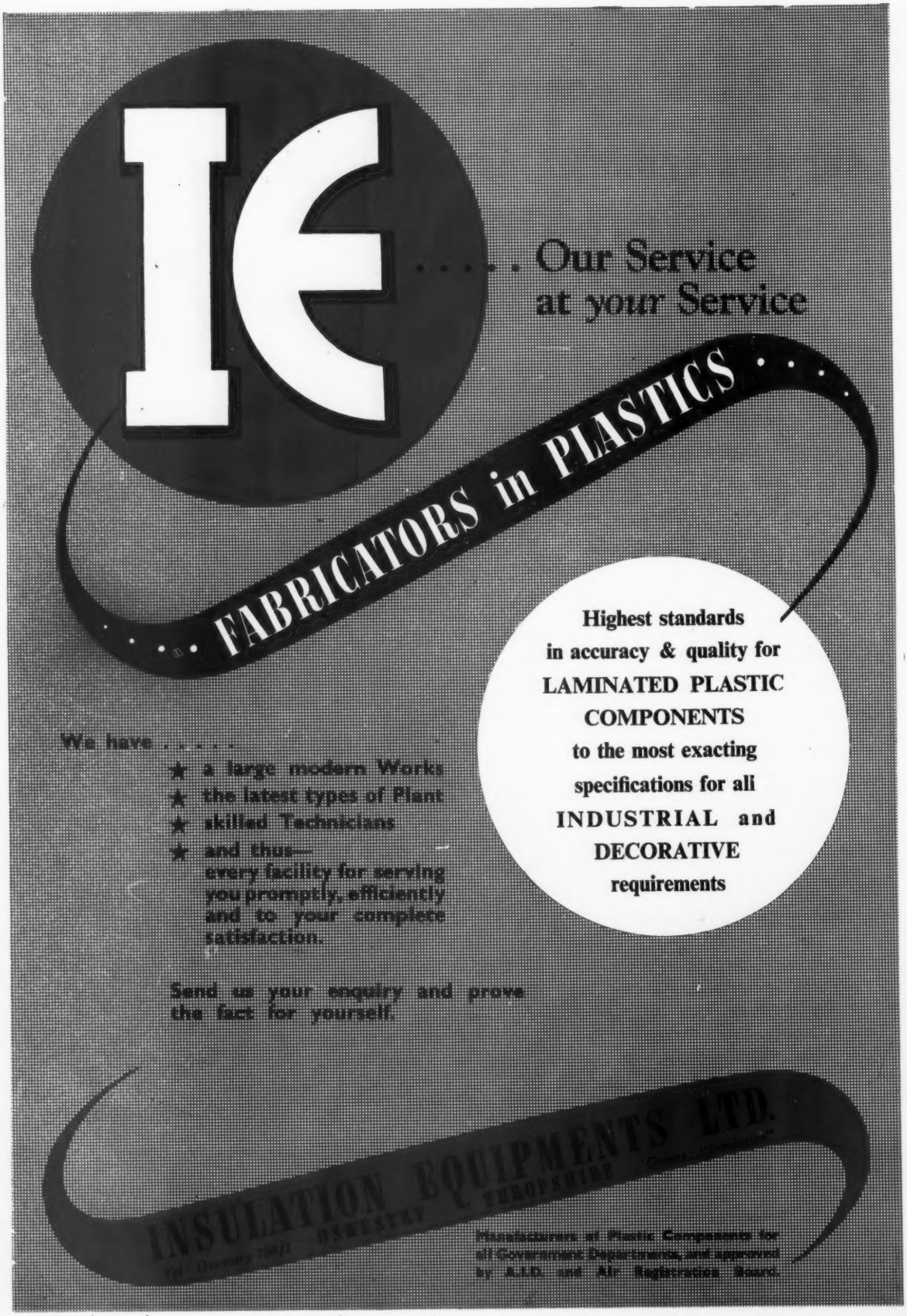
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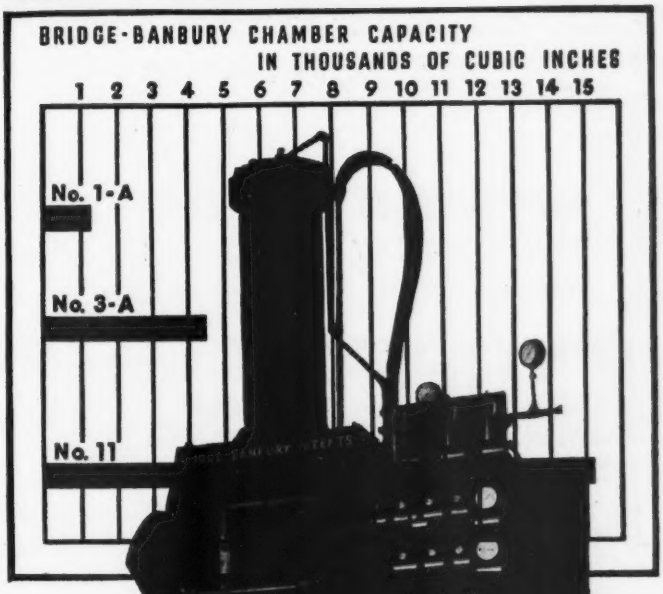

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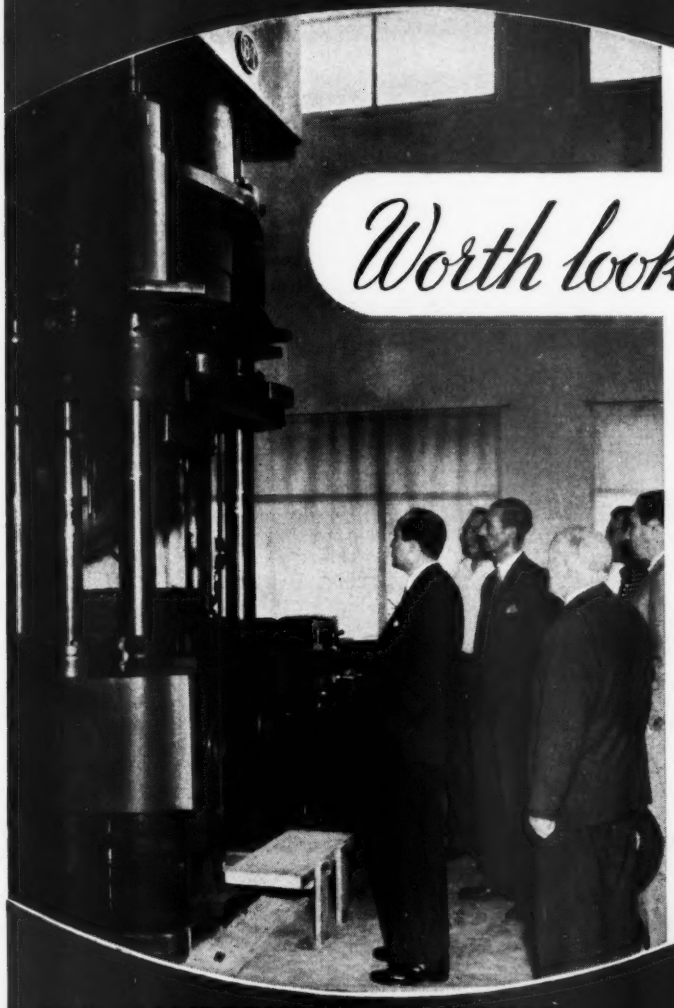

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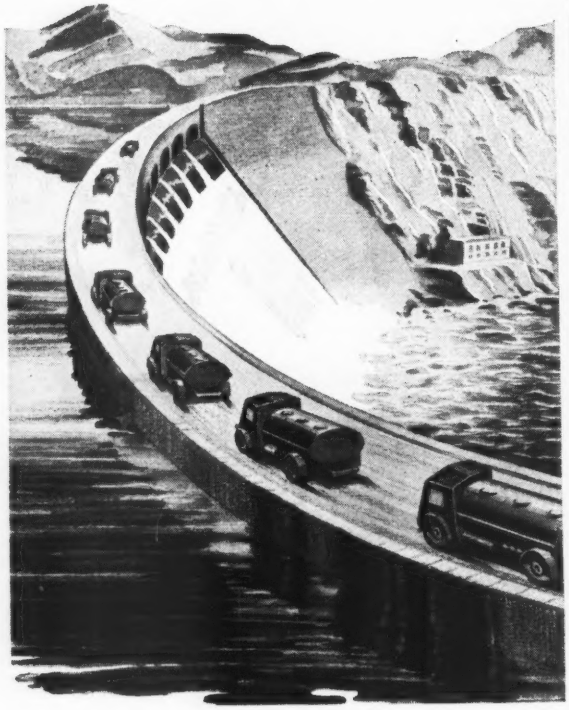

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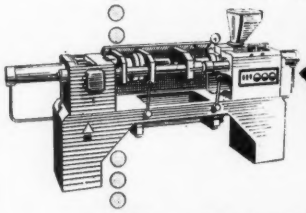

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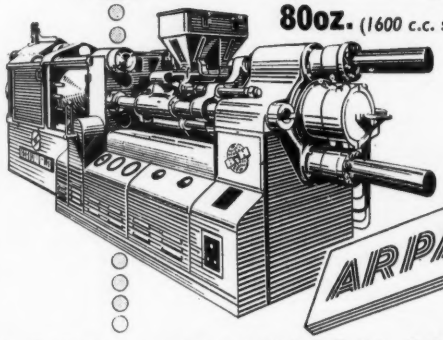

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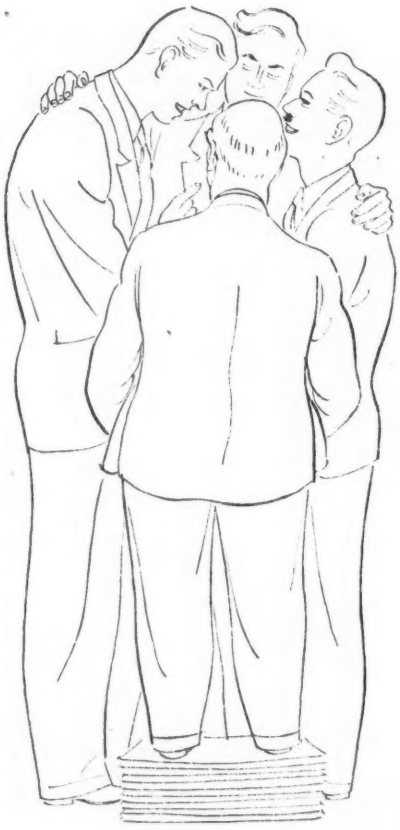

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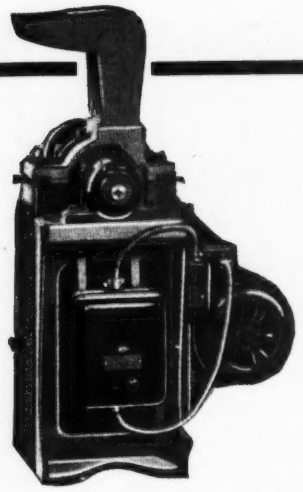

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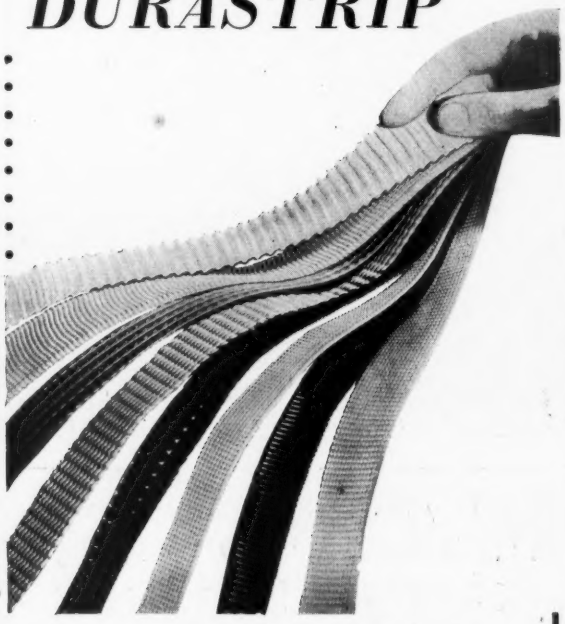

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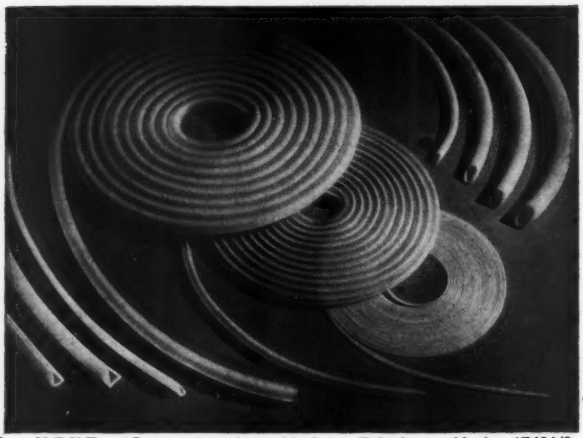

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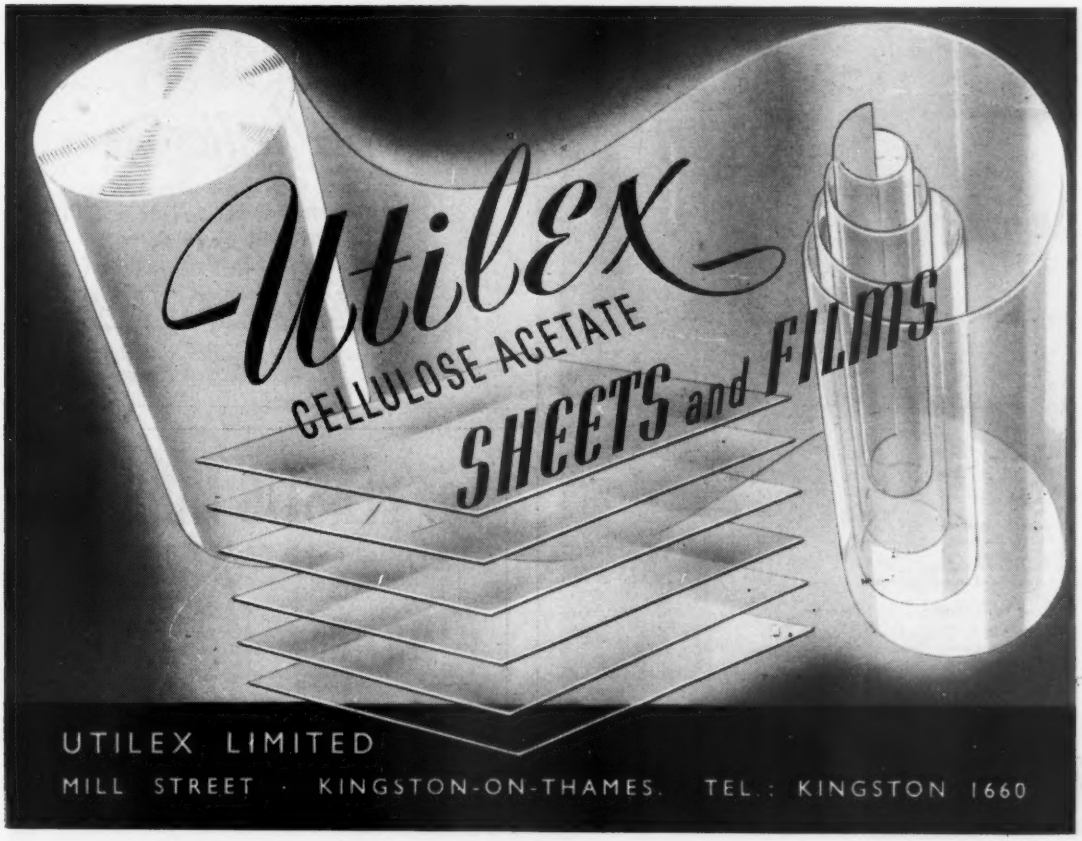

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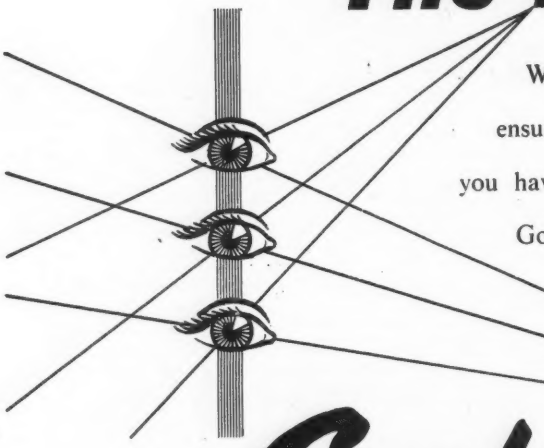

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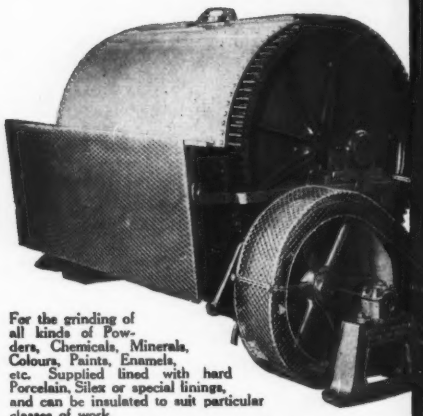

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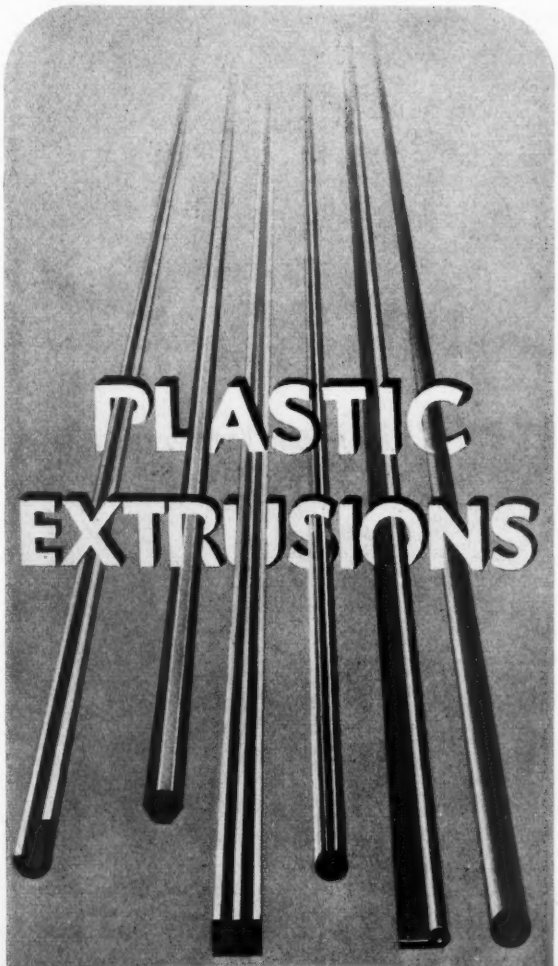

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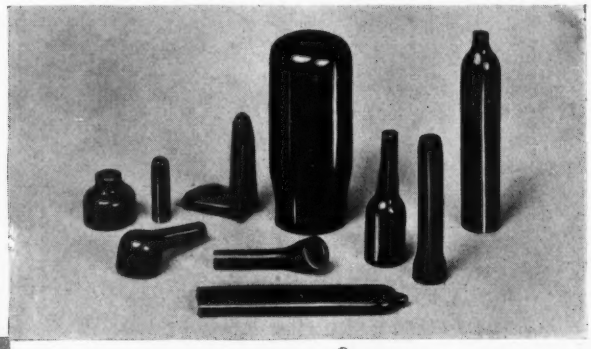

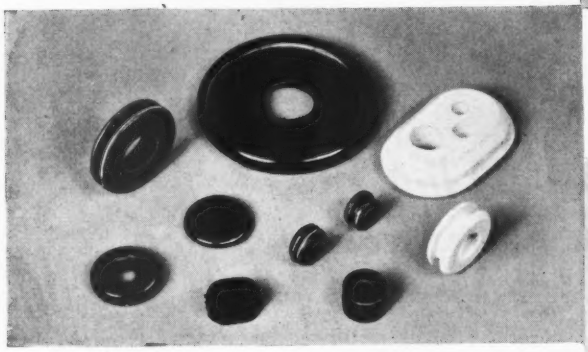

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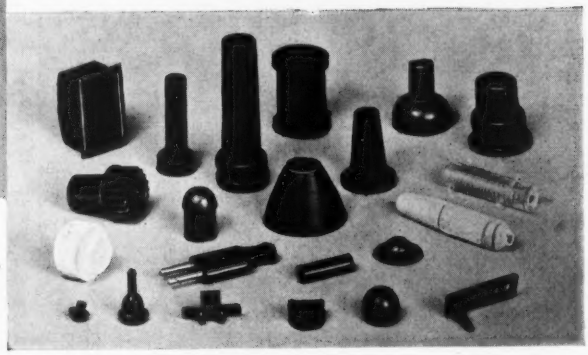

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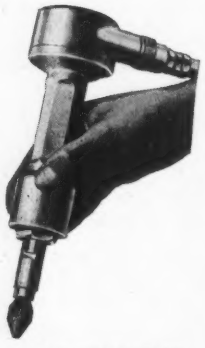

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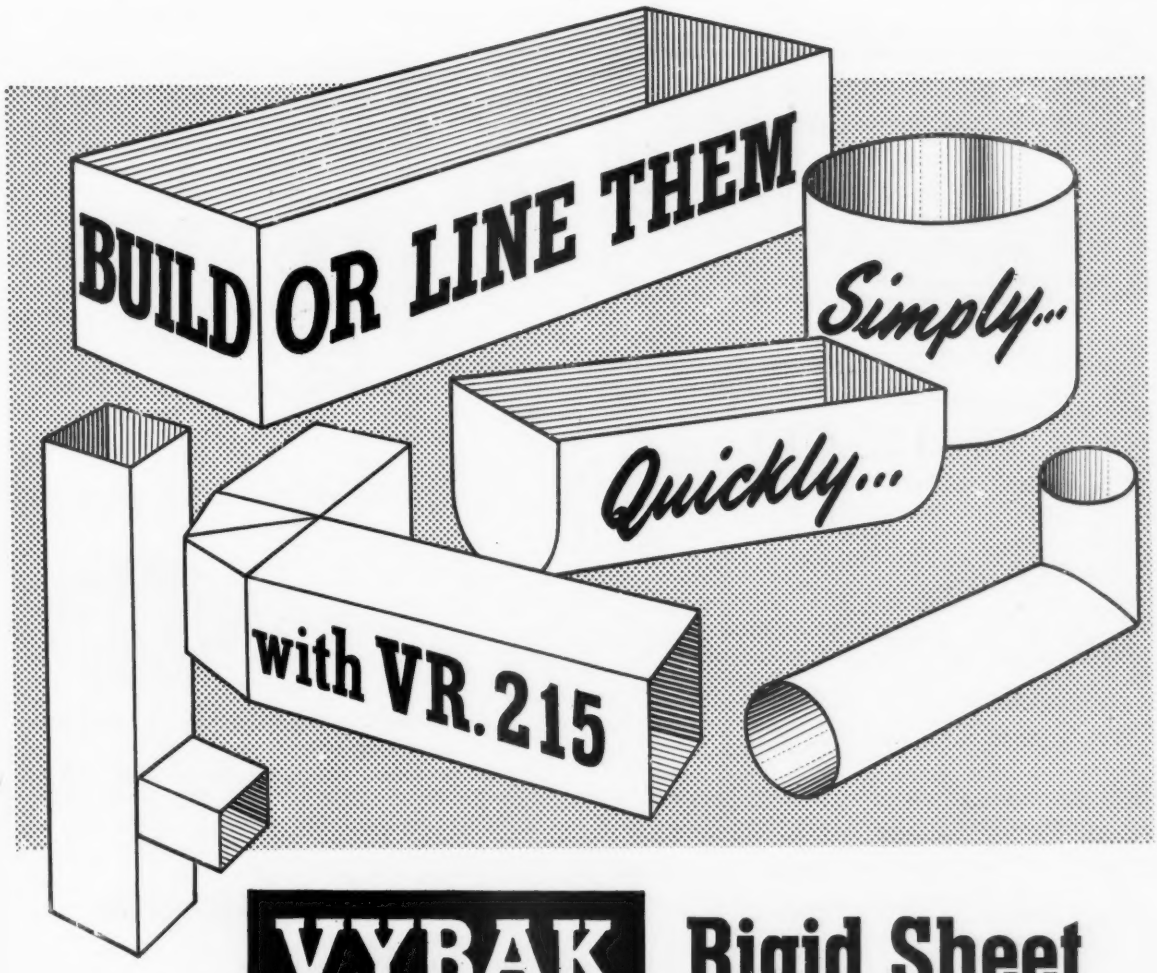

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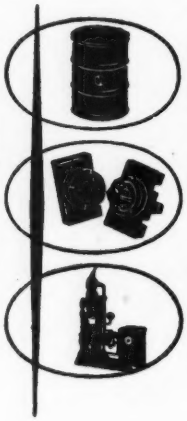

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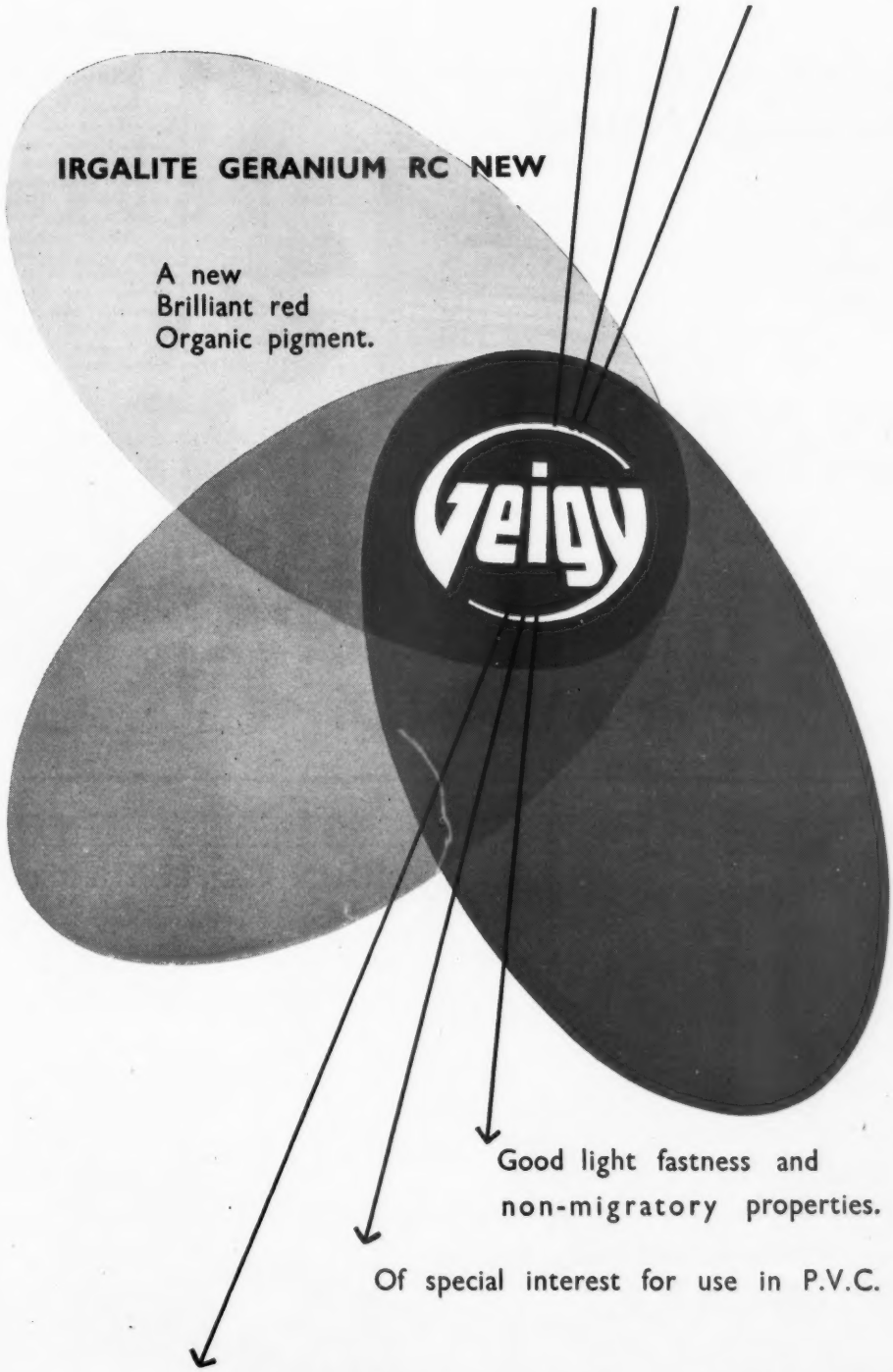

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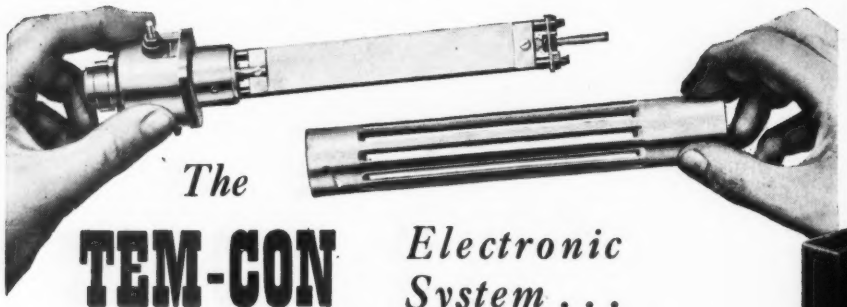

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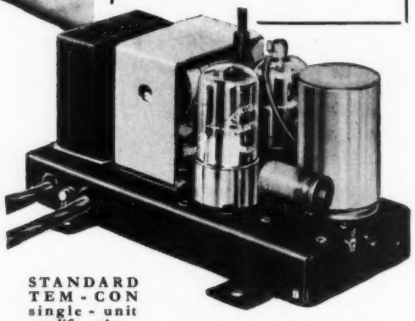

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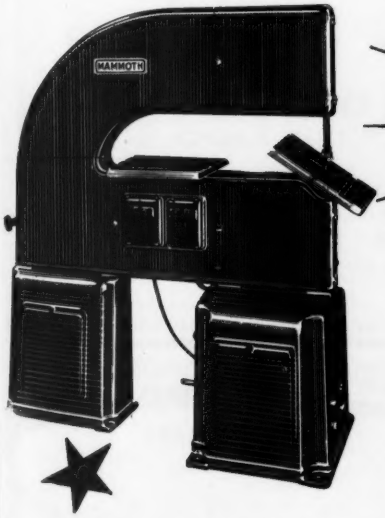

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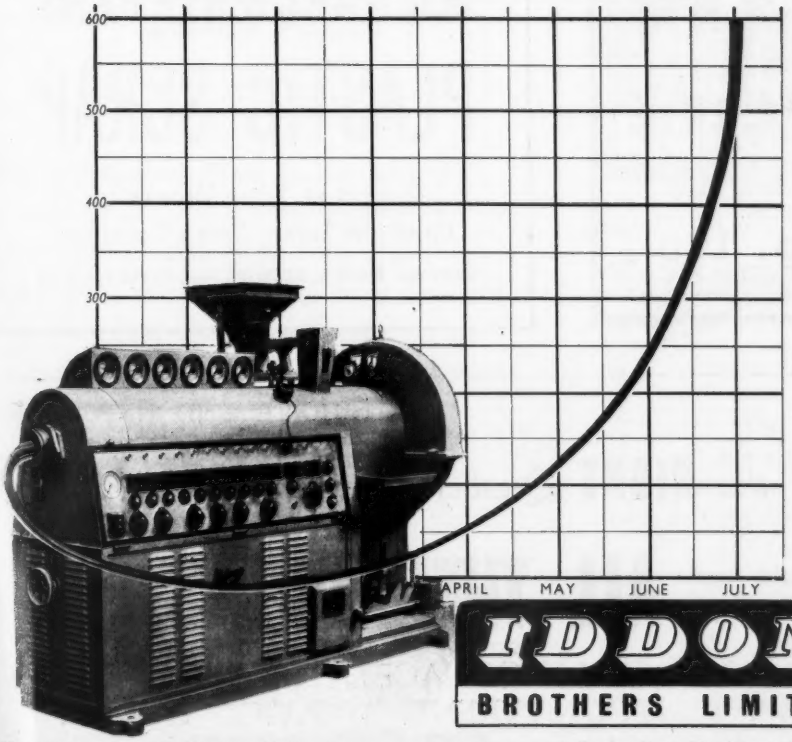

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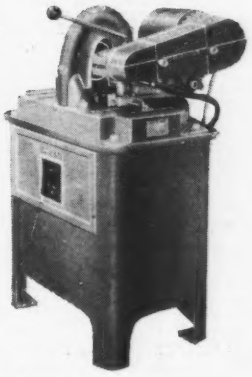

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250-tons Upstroke Press by Henry Berry. 15 in. dia. Fescolised ram by 20 in. stroke. Four columns 2 ft. by 1 ft. between. Table area 2 ft. by 22 in. Daylight 20 in. W.P. 1½ tons.

200-tons Downstroke Press by Hydraulic Eng. Co. D/a piston type ram 14½ in. dia. by 13 in. dia. rod by 20 in. stroke, arranged for prefilling. Table area 30 in. by 21 in. Daylight 30 in. Below fixed table; ejector ram D/a piston type 3⅞ in. by 3⅜ in. dia. rod by 4½ in. stroke, constant pressure return. Self-contained Pump, motor, control valve, supply tank, etc.

150-tons Downstroke Press by Francis Shaw. 14 in. dia. ram by 2¾ in. side pullbacks by 26 in. stroke. Four columns 28 in. by 12 in. between. Table area 28 in. by 26½ in. Daylight 28 in. Below fixed table 4½ in. dia. ram by 12 in. stroke, working through hole in table. Arranged for automatic prefilling. W.P. 1 ton.

120-tons Downstroke Press by Hydraulic Eng. Co. D/a piston type ram 8¾ in. by 7⅞ in. dia. rod by 14 in. stroke. Fabricated frame. Table area 2⅞ in. by 21 in. Daylight 24 in. Below fixed table; ejector ram D/a piston type 3 in. dia. by 2⅝ in. rod, by 4½ in. stroke. Self-contained Pumping Equipment, etc. W.P. 2 tons.

Two 100-tons Upstroke Presses by T. H. and J. Daniels. 12 in. dia. main ram, two side pullbacks by 12 in. stroke. Four columns 20½ in. by 10½ in. between. Table area 30 in. by 20½ in. Daylight 22¾ in. Each fitted with wire guards and Towler "Electraulic" Pump.

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BEST CASH PAYMENTS.
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The engagement of persons answering advertisements in respect of vacant situations must be made through a local office of the Ministry of Labour, or a scheduled employment agency, if the applicant is a man between the ages of 18 and 64 inclusive or a woman between the ages of 18 and 59 inclusive, unless he or she, or the employment, is excepted from the provisions of Notification of Vacancies Order, 1952.

PLASTIC EMULSIONS. Technical organizer required to start new department. Write full particulars to Dohm, Ltd., 167 Victoria St., London, S.W.1. 197-18

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THE ENGLISH ELECTRIC CO., LTD., LUTON, invite applications from engineers for experimental work on structural plastics for the guided weapon industry.
Duties will include design of components, preparation of drawings for rigs and equipment and supervision of laboratory personnel. A previous experience of plastics is not essential, but applicants must have a thorough engineering background and an imaginative approach to new and untried techniques and processes.
Applications stating age, experience and qualifications, to Dept. C.P.S., 336-7 Strand, W.C.2, quoting Ref. 1086A. 198-13

MIDLANDS REPRESENTATIVE required for well-known firm of London injection moulders, preferably with established connection among users of thermoplastic mouldings.
Write stating full details of experience, etc., and salary required to Box P9711, care of "Plastics." 197-17

FIRST-CLASS CHEMIST required by progressive public company in the North-West, for research and development on synthetic resins and allied materials, good degree and previous experience desirable, salary range £1,000-£1,300 per annum, a staff superannuation scheme is in operation.
Applicants are requested to give details of their age, qualifications and previous experience. Box P9710, care of "Plastics." 197-15

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WANTED, young man, single, 24-26 years, for training prior to appointment as technical representative for plastics raw materials manufacturers, Gloucester area.
Must be prepared to work in other parts of the country after training. Box P975, care of "Plastics." 197-19

WANTED, experienced plastic moulder to take charge of small new plant and production in North Wales.
Reply in the first instance by letter, stating age, experience and present salary.
Give full details including salary expected. Box P974, care of "Plastics." 197-20

Situations Vacant (contd.)

EXECUTIVE ENGINEER wanted, must be fully conversant with injection and transfer moulding processes and have first-class knowledge of press tools, must be able to control staff and supervise production of precision mouldings for new factory shortly to be opened in Letchworth, good salary and prospects. Write giving full details in confidence to Box P972, care of "Plastics." 197-x2437

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This is not a desk job, but to a candidate who proves that he has got what it takes, prospects are particularly bright. Apply in confidence to Box P9713, care of "Plastics." 197-10

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SITUATIONS WANTED

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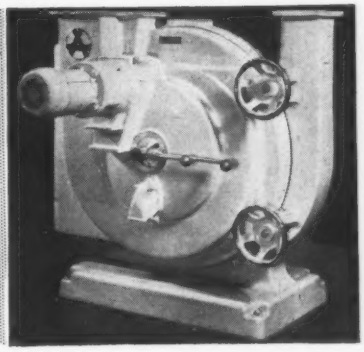

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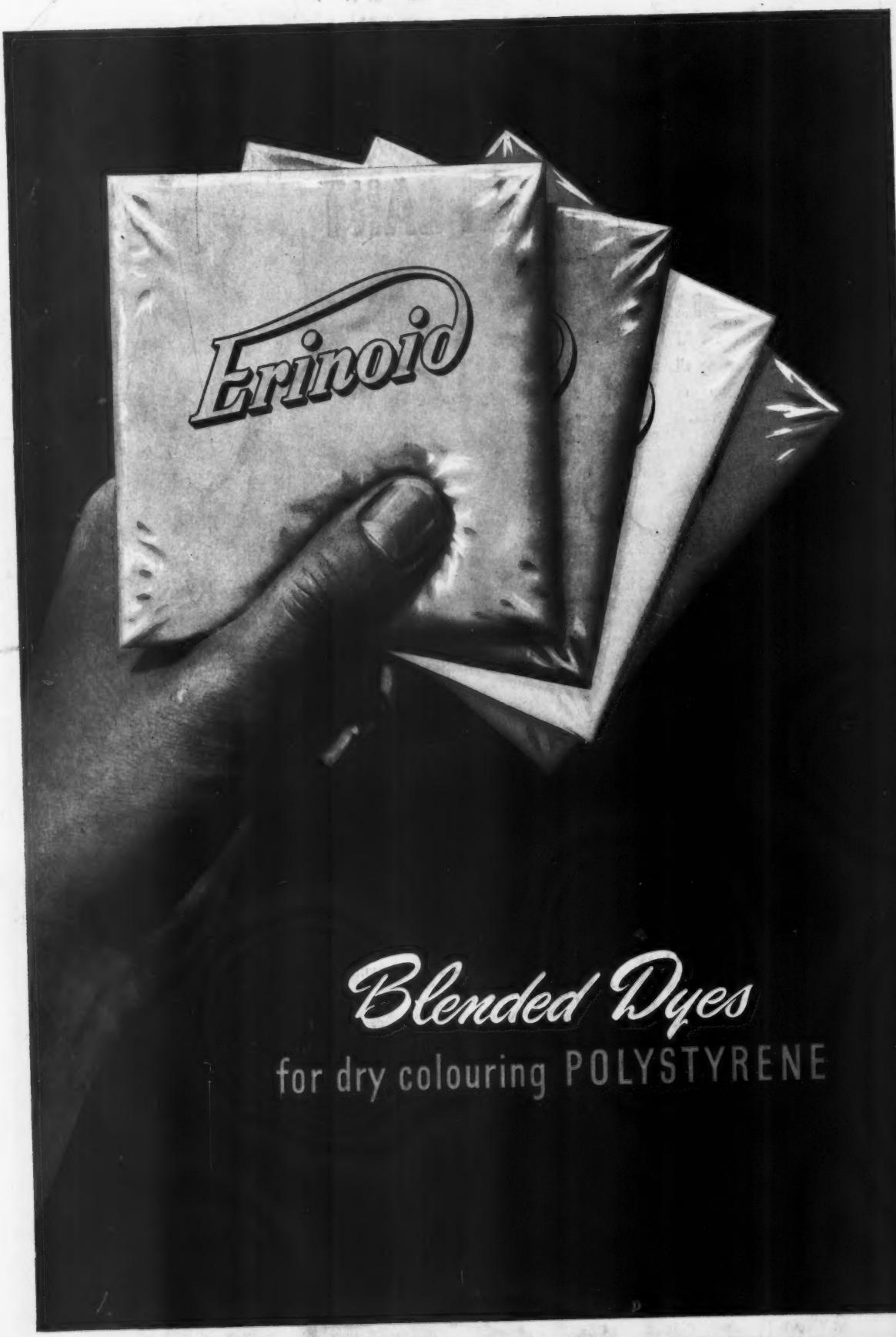

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